Firm Pay Dynamics

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AKM Conference

Motivation

- Growing interest in employers vis-à-vis earnings dispersion
  - Measurement: AKM ('99) to Card et al. ('19)
  - Methods: AKM ('99) to Bonhomme et al. ('19)
- Common approach: control for employer identity
- Leaves open two important questions:
  1. Why do some employers pay more than others?
  2. How permanent are employer pay policies?

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What We Do

We investigate firm pay in cross-section & over time by combining

- linked employer-employee data from Sweden,
- register data on individual characteristics for all workers,
- income statement & balance sheet data for all firms

in order to

1. estimate AKM equation augmented with firm-year fixed effects
2. relate (dynamics of) firm pay to (dynamics of) firm financials
3. measure static & dynamic sorting between workers & firms

Main Findings

1. 50% greater role for firm heterogeneity w/ dynamic pay policies
2. Firm-year pay related to firm financials ($R^2 = 0.385$)
3. Fluctuations ($RMSE = 0.056$) and mean reversion ($\rho = 0.865$)
4. Changes in firm-year pay related to changes in firm financials
5. Sorting is positive in cross section but negative over time

Contribution to Literature

I. Why do some employers pay more than others?

- Pure wage dispersion (Burdett & Mortensen '98)
- Productivity (AKM '99; Barth et al. '16; Card et al. '16; Alvarez et al. '18)
- Productivity + search frictions + minimum wage (Engbom & Moser '19)
- Productivity + selection into trade (Helpman al. '17)
- Productivity + compensating differentials + technology (Lamadon et al. '19)
- Amenities (Sorkin '18)
- Prod. + search frictions + tech. + amenities + discrim. (Morchio & Moser '19)

II. Dynamics of employer pay

- van Reenen ('96); Guiso et al. ('05); Lemieux et al. ('09); Schmieder ('13); Card et al. ('14); Lamadon ('16); Ellul et al. ('17); Garin & Silvério ('18); Babina et al. ('19); Kline et al. ('19); Moser et al. ('19)

III. Sorting between workers & employers

- AKM ('99); Andrews et al. ('08, '12); Eeckhout & Kircher ('11); Gulyas ('17); Lopes de Melo ('18); Borovickova & Shimer ('18); Bonhomme et al. ('19); Lentz et al. ('19)

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Data

Data

- Admin. linked employer-employee data from Sweden, 2004–2015
- All employed men & women of age 18–64
- App. 1.3–1.8 million unique workers per year
- Monthly earnings = salary + wages + bonuses
- Main advantage: rich data on worker and firm observables

Worker-Level Observables

Worker demographics

- Gender, age, place of birth

Family characteristics

- Family ID, municipality of residence, number & age of children

Educational background

- Highest academic degree completed
- High school ID, high school specialization, high school grades
- College ID, college field of study, college degree type
- Cognitive & noncognitive skills test scores (enlistment)

Skill and job characteristics

- Experience, job tenure, hours (sample), occupation (sample)

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Firm-Level Observables

Firm demographics

- Age, size, incorporation status, sector, region

Income statement

- Sales, value added, EBIT, total labor costs, wage bill, investment

Balance sheet

- Short-term & long-term assets, debt, equity

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Summary Statistics, 2004–2015

	Mean	Std. dev.
Panel A. Worker-level variables		
Worker age (years)	39.62	11.10
Share with college degree	0.213	
Monthly earnings (log SEK)	10.25	0.48
Panel B. Firm-level variables		
Firm size (thousands of employees)	1.42	3.05
Firm age (years)	19.20	8.37
Sales (billion SEK)	4.60	10.45
Value added (billion SEK)	1.28	4.13
Assets (billion SEK)	5.48	2.34
Debt (billion SEK)	2.61	9.19
Equity (billion SEK)	2.87	10.84
Investment (billion SEK)	0.13	0.53
Observations	18,412,038	

Measuring Worker & Firm Pay Heterogeneity

First Stage: Estimating Worker and Firm-Year FEs

First stage: Estimate AKM equation with firm-year FEs, letting

$$y_{it} = \alpha_i + \psi_{jt} + X_{it}\beta + \varepsilon_{it},$$

for individual i employed at firm $j = J(i,t)$ in year t, where

- y_{it} is log earnings,
- α_i is a worker FE,
- ψ_{jt} is a firm-year FE,
- X_{it} is a set of restricted age FEs, and
- ε_{it} is an error term.

Identification of Model with Firm-Year FEs

▸ Illustration

Essentially, workers & firms in connected set determined as usual

Model with firm FEs (AKM):

- "Physical firms" can exist for multiple years
- Identification for workers and "physical firms" in connected sets
- Connected sets defined by switches between "physical firms"
- Workers moving between "physical firms" constitute switches

Model with firm-year FEs (generalization of AKM):

- "Physical firms" switch identity each year
- Identification for workers and firm-years in connected sets
- Connected sets defined by switches between firm-years
- All repeat worker observations constitute switches

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First Stage Results: Variance Decomposition

Firm FEs Wages

First-stage AKM equation: $y_{it} = \alpha_i + \psi_{jt} + X_{it}\beta + \varepsilon_{it}$

	(1)	(2)	(3)	(4)	(5)
$Var\left(y_{ijt}\right)$	0.235	0.230	0.231	0.234	0.235
$Var\left(\widehat{\alpha}_i\right)$	0.124	0.121	0.125	0.130	0.132
$Var\left(\widehat{\psi}_{jt}\right)$	0.044	0.028	0.022	0.019	0.019
$Var\left(X_{it}\widehat{\beta}\right)$	0.025	0.024	0.022	0.020	0.019
$2 \times \sum Cov\left(\cdot\right)$	0.000	0.011	0.016	0.018	0.018
$Var\left(\widehat{\varepsilon}_{ijt}\right)$	0.044	0.046	0.047	0.047	0.047
$Corr\left(\widehat{\alpha}_i, \widehat{\psi}_{jt}\right)$	0.011	0.094	0.124	0.129	0.127
Observations	21,145,007	18,425,427	15,091,142	11,313,701	9,392,584
Unique workers	3,056,376	2,801,551	2,437,724	1,959,034	1,685,029
Unique firms	2,134,700	628,190	202,346	51,833	23,761
Largest connected set	98.1%	99.9%	100.0%	100.0%	100.0%
R^2	0.814	0.799	0.798	0.801	0.802
Firm FE type	Firm-year	Firm-year	Firm-year	Firm-year	Firm-year
Income concept	Earnings	Earnings	Earnings	Earnings	Earnings
Minimum firm size	0	5	15	50	100

Summary: Firm-Year FE Specification

Firm-year FEs

1. account for significant share of earnings dispersion (10%)
2. account for significantly more (+50%) than firm FEs (6%)
3. are relatively constant in Var & Corr for minimum firm size ≥ 15

Second Stage: Accounting for Worker and Firm-Year FEs

Second stage: Project estimated FEs from AKM equation

$$y_{it} = \alpha_i + \psi_{jt} + X_{it}\beta + \varepsilon_{it}$$

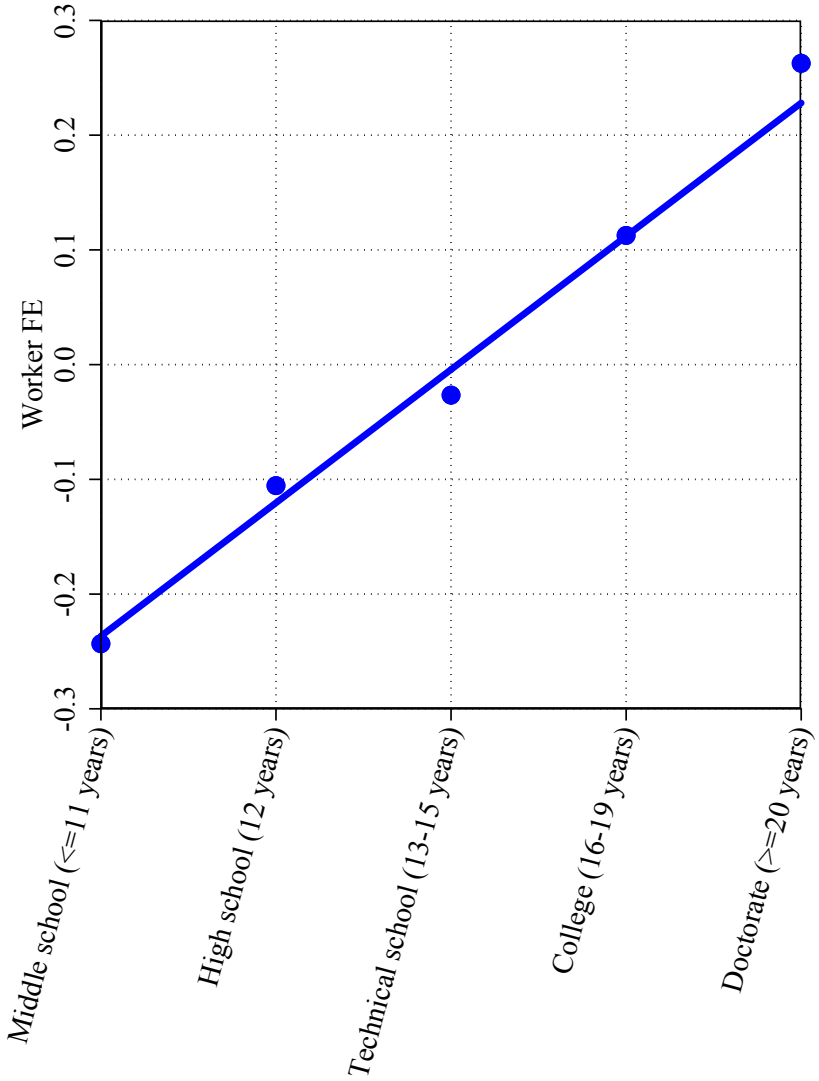
on observables:

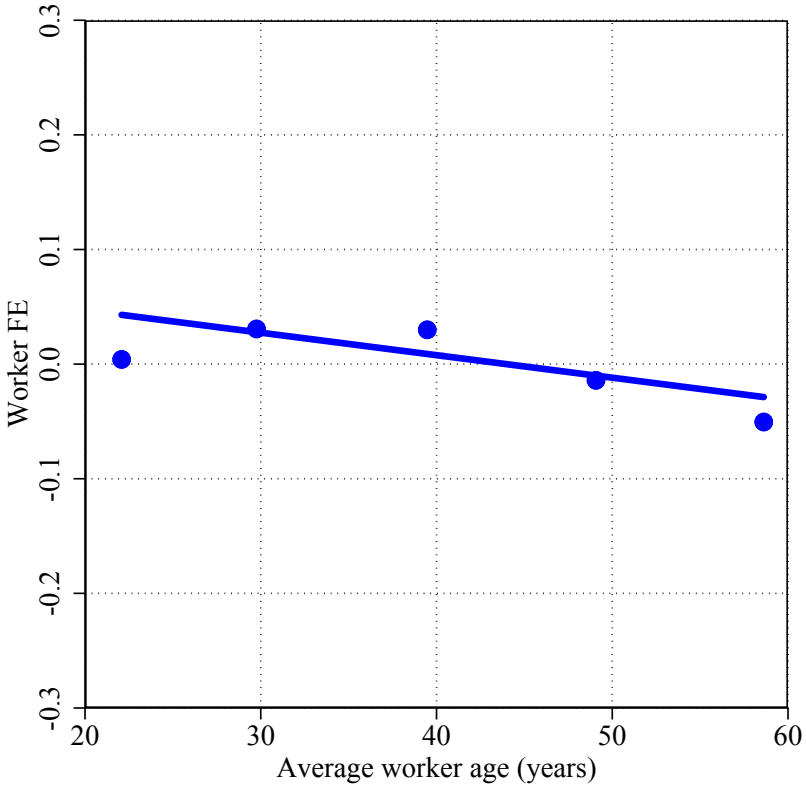
$$\widehat{\alpha}_i = Z_i^W \gamma + \eta_i^W,$$
$$\widehat{\psi}_{jt} = Z_{jt}^F \delta + \eta_{jt}^F,$$

for individual i and firm j in year t, where

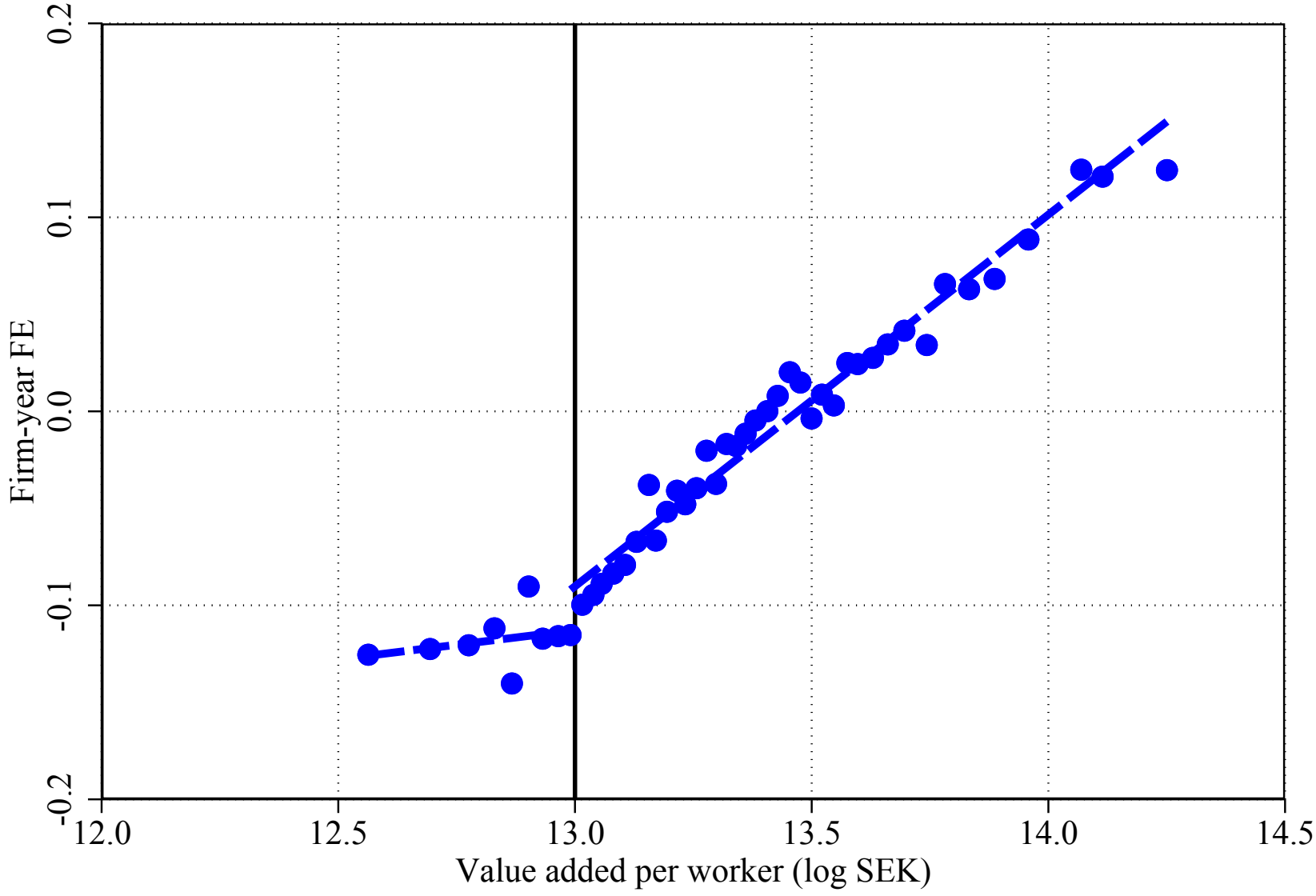
- $\widehat{\alpha}_i$ is the estimated first-stage worker FE,
- Z_i^W is a vector of observable worker characteristics,
- η_i^W is a worker-side error term,
- $\widehat{\psi}_{jt}$ is the estimated first-stage firm-year FE,
- Z_{jt}^F is a vector of observable firm characteristics, and
- η_{jt}^F is a firm-side error term.

Second Stage: Worker Pay & Observables





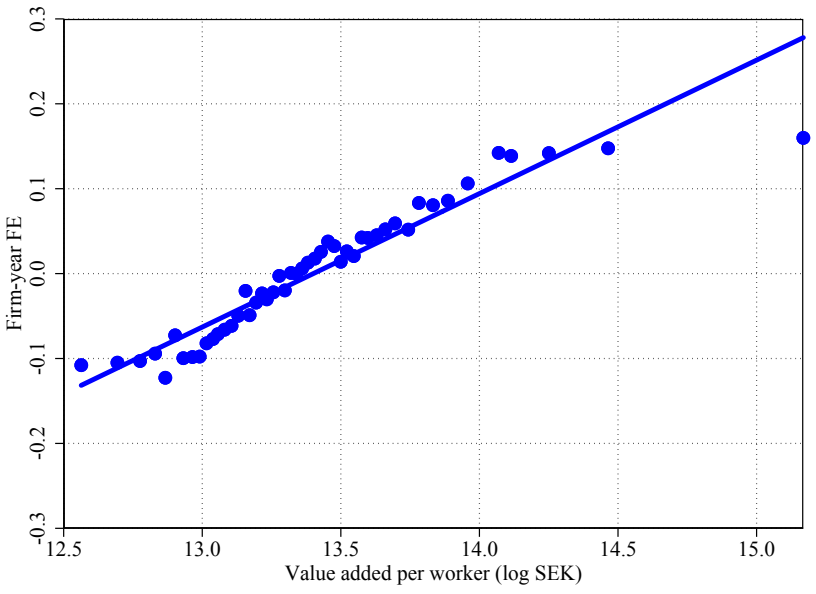
Second Stage: Firm Pay & Value Added per Worker

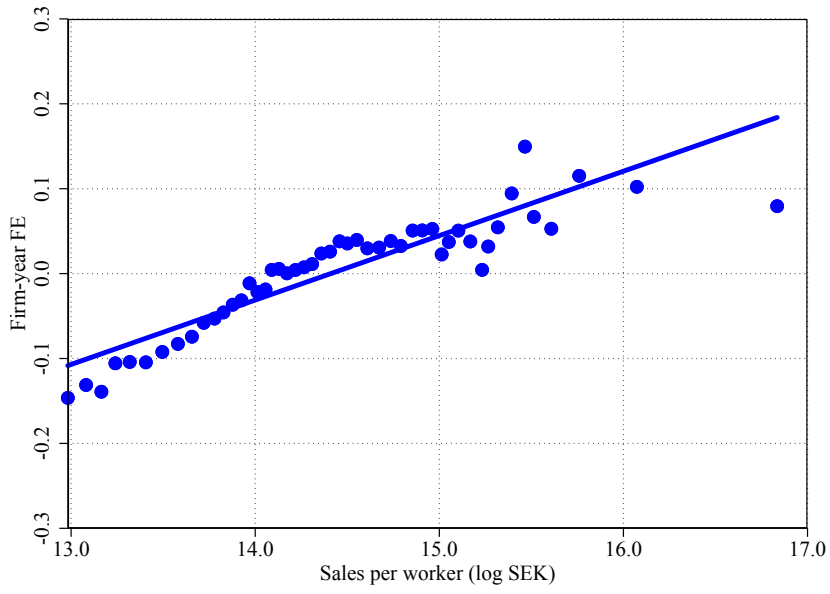


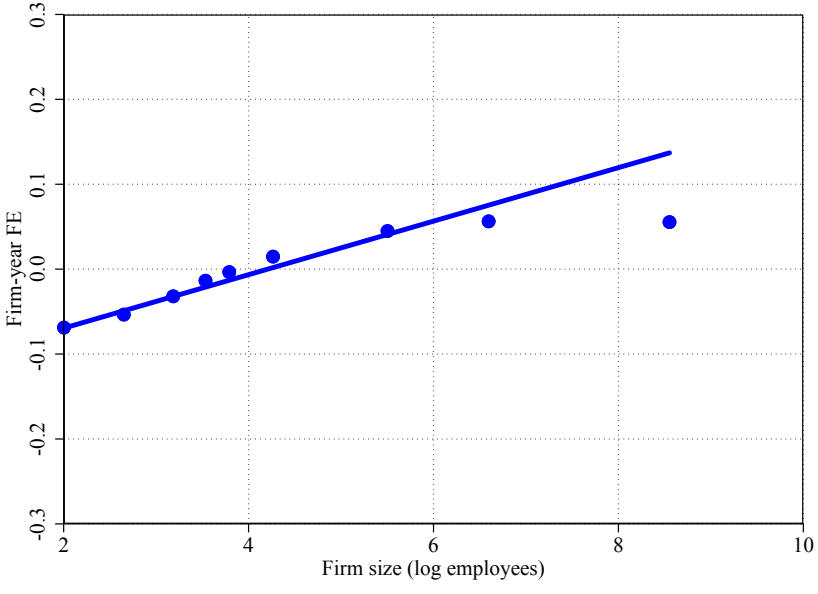
Note: exp(13.0) SEK ≅ 450,000 SEK ≅ USD 50,000.

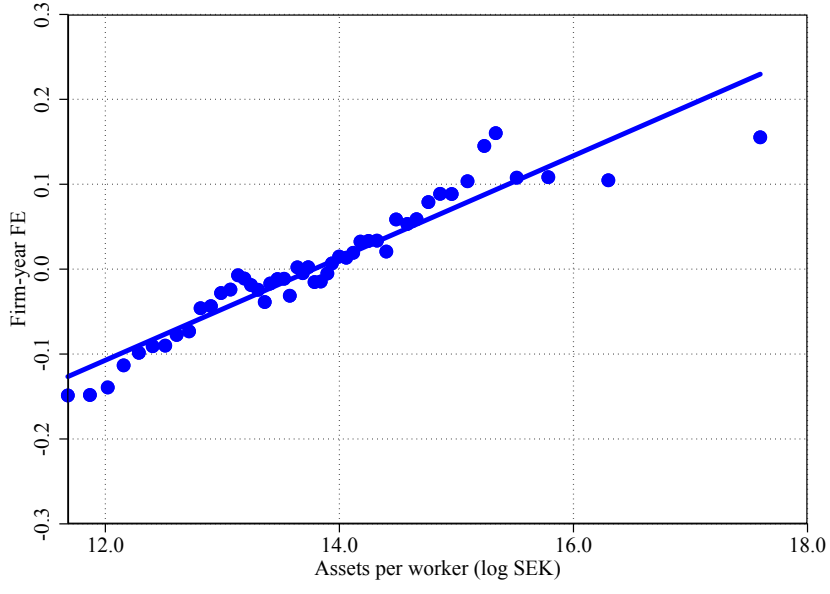
Second Stage: Firm Pay & Observables

▸ By size ▸ By age









Second Stage: Regression Results

▸ Adding Firm FEs ▸ Larger minimum firm size

Second-stage equation: $\widehat{\psi}_{jt} = Z^F_{jt}\delta + \eta^F_{jt}$

	(1) Univariate	(2) Multivariate
Firm size (log employees)	0.023	0.008
Firm age (years)	0.035	-0.002
Sales per worker (log SEK)	0.070	0.013
Value added per worker (log SEK)	0.121	0.056
Assets per worker (log SEK)	0.056	0.014
Debt per worker (log SEK)	0.056	0.018
Equity per worker (log SEK)	0.036	0.004
Investment per worker (log SEK)	0.022	-0.004
Observations	13,865,483	13,865,483
R^2		0.385
Year FE	Yes	Yes
Income concept	Earnings	Earnings
Minimum firm size	15	15

Summary: Covariates of Firm-Year FEs

Firm-year FEs

1. are linked to more than one firm characteristic
2. are most strongly related to firm productivity (v.a.p.w.)
3. are about 40% accounted for by simple firm-level observables

Firm Pay Dynamics

Dynamic Firm Pay Policies

- How dynamic vs. fixed are firm pay policies?
  - I.e., does firm-year FE vs. firm FE specification matter?
- Starting point: autoregressive model

$$\widehat{\psi}_{jt} = \sum_{\tau=1}^{T} \rho_\tau \widehat{\psi}_{jt-\tau} + \kappa_j + \gamma_t + \zeta_{jt},$$

for firm j in year t, where

- $\widehat{\psi}_{jt}$ is estimated firm-year FE,
- κ_j is a firm FE,
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- ζ_{jt} is an error term.

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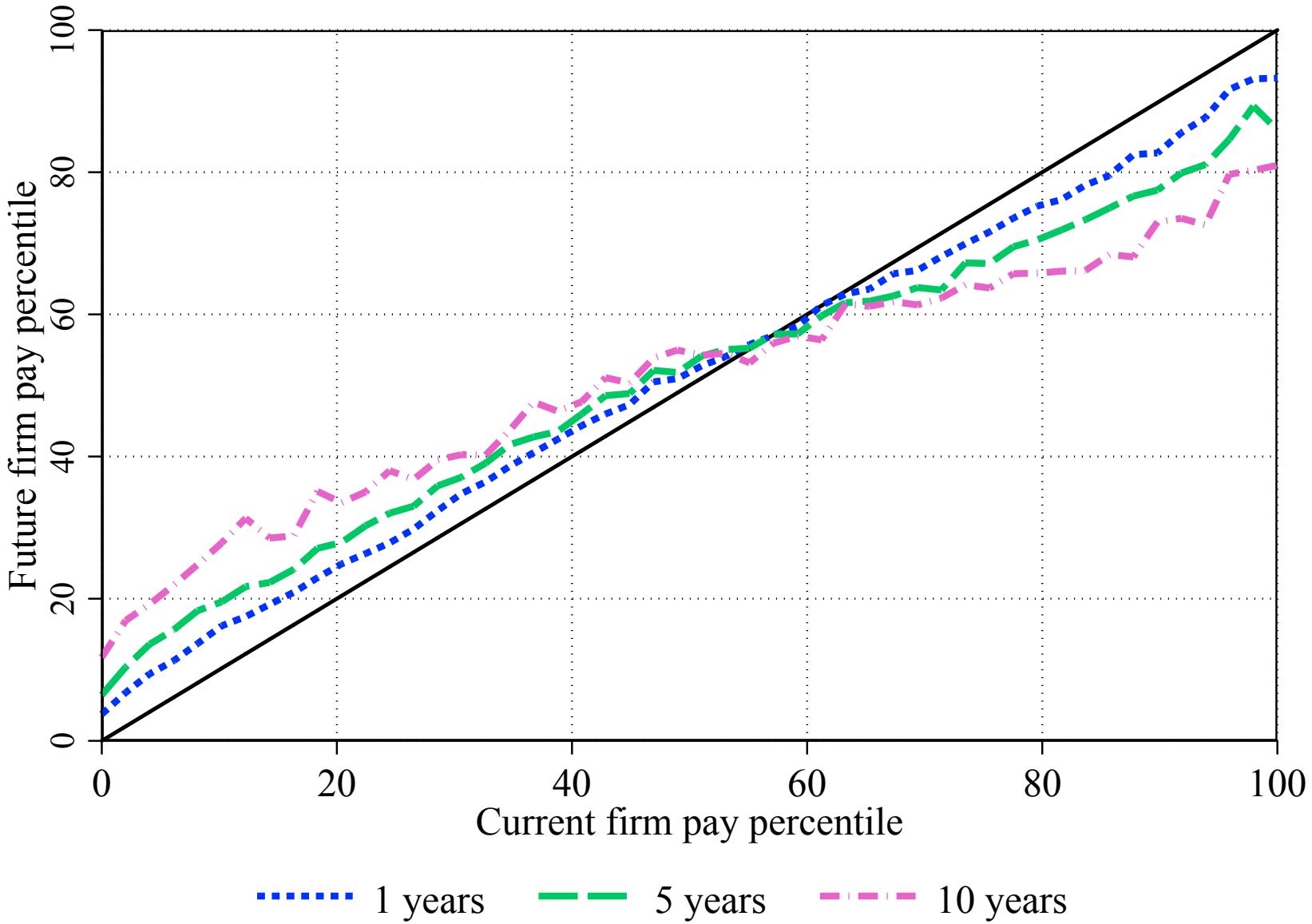
Idiosyncratic Variation and Autocorrelation Structure

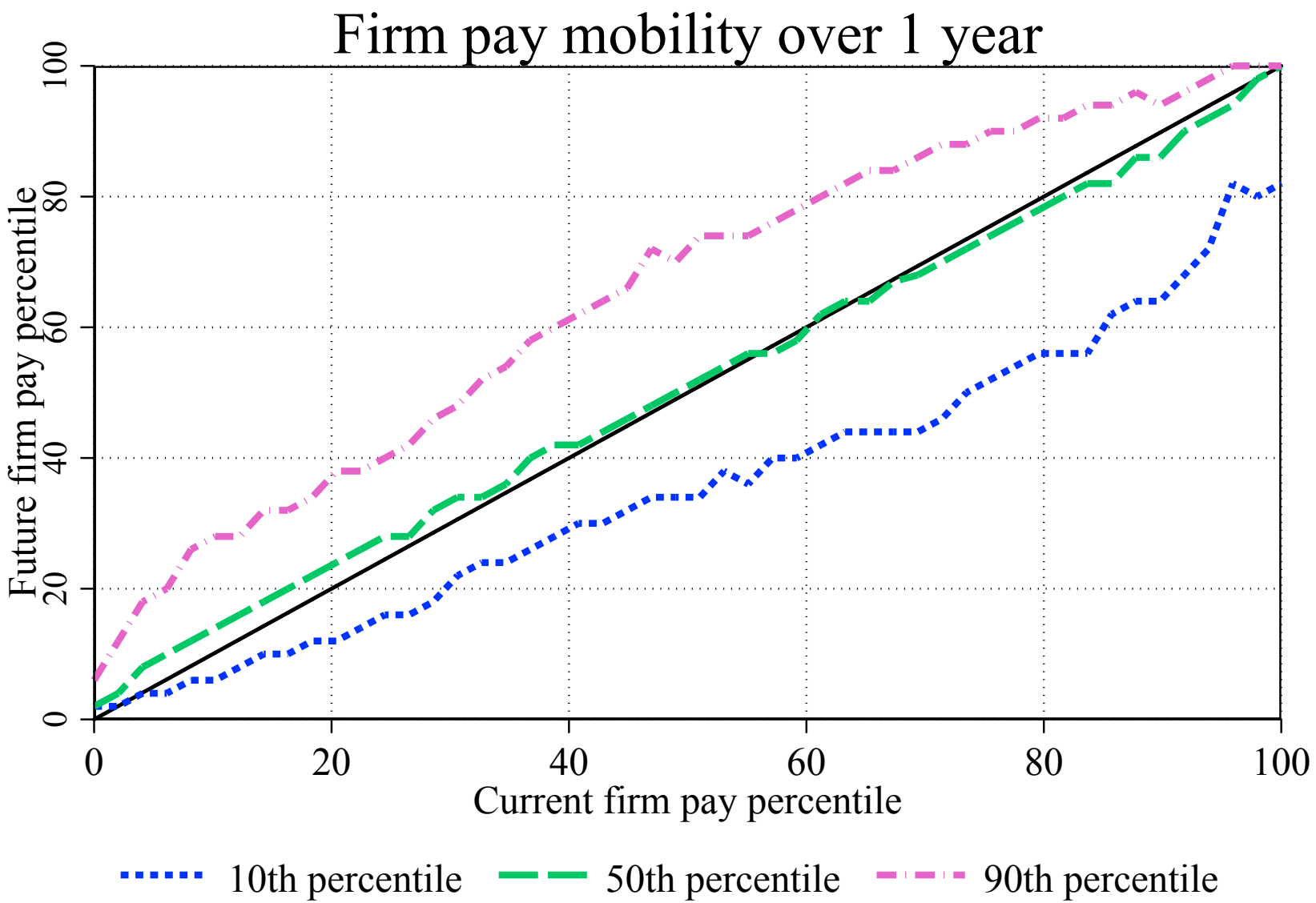
Autoregressive model: $\widehat{\psi}_{jt} = \sum_{\tau=1}^{T} \rho_\tau \widehat{\psi}_{jt-\tau} + \kappa_j + \gamma_t + \zeta_{jt}$

	(1)	(2)	(3)	(4)	(5)
1-year lagged firm-year FE			0.865	0.817	-0.123
2-year lagged firm-year FE				-0.047	-0.023
3-year lagged firm-year FE				0.157	-0.034
4-year lagged firm-year FE				0.057	0.020
5-year lagged firm-year FE				0.011	0.015
6-year lagged firm-year FE				0.003	0.035
7-year lagged firm-year FE				0.004	0.028
8-year lagged firm-year FE				-0.012	0.007
9-year lagged firm-year FE				0.044	0.040
10-year lagged firm-year FE				-0.061	0.021
Observations	16,702,161	16,417,694	14,641,860	1,943,154	1,875,897
R^2	0.107	0.842	0.748	0.870	0.983
RMSE	0.135	0.056	0.070	0.046	0.017
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	No	Yes	No	No	Yes

Firm Pay Mobility, Mean



Firm Pay Mobility, Percentiles



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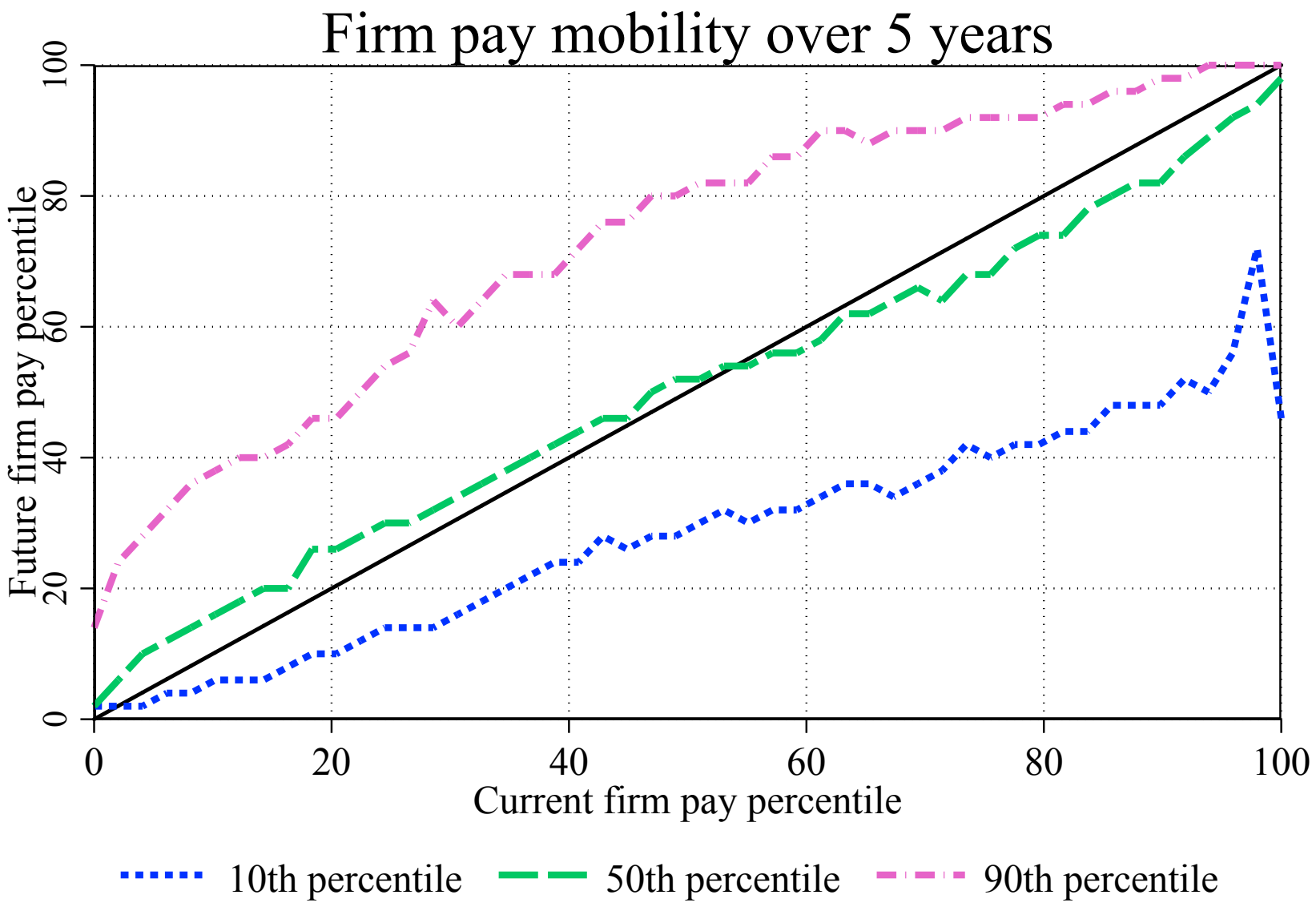

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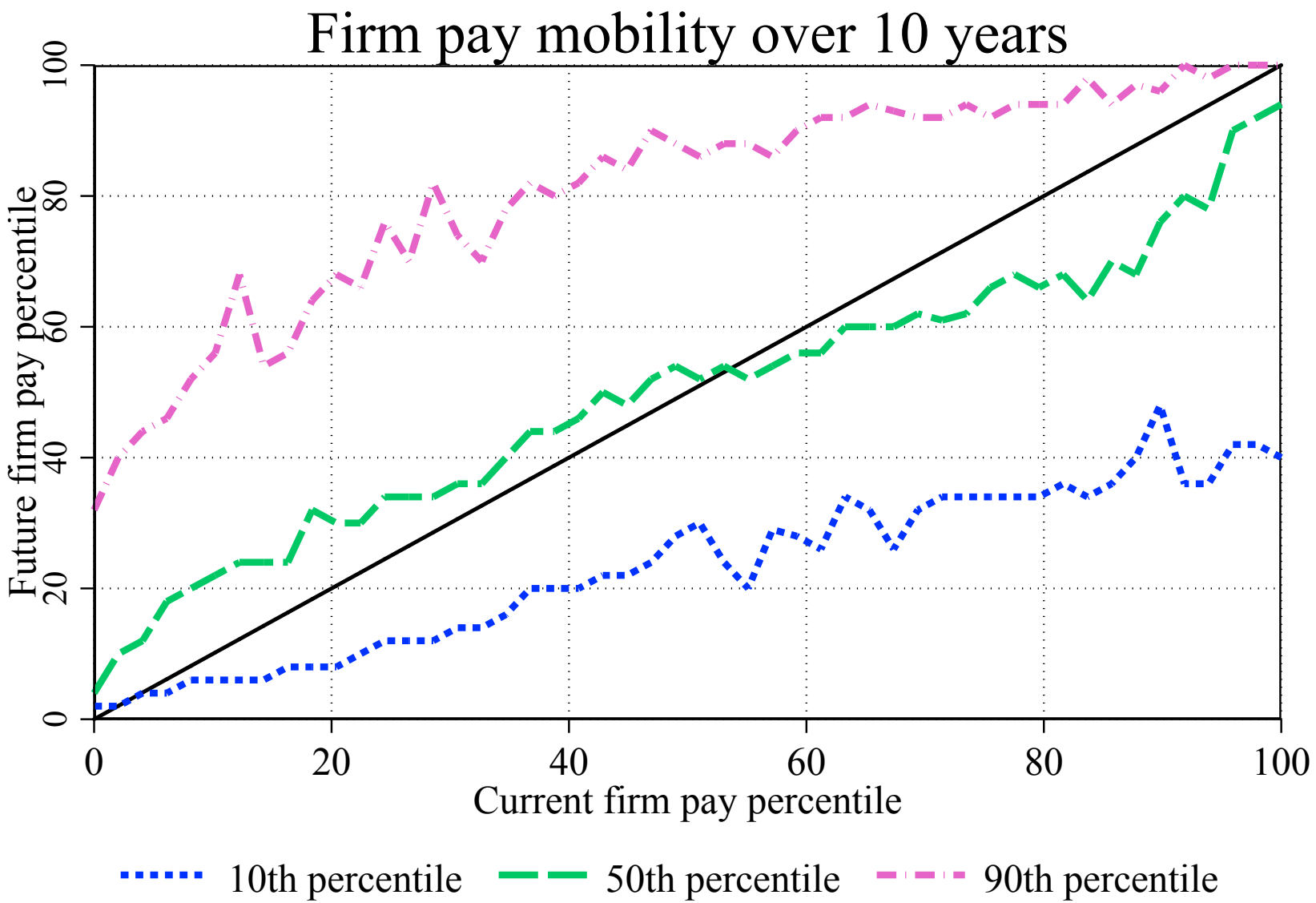
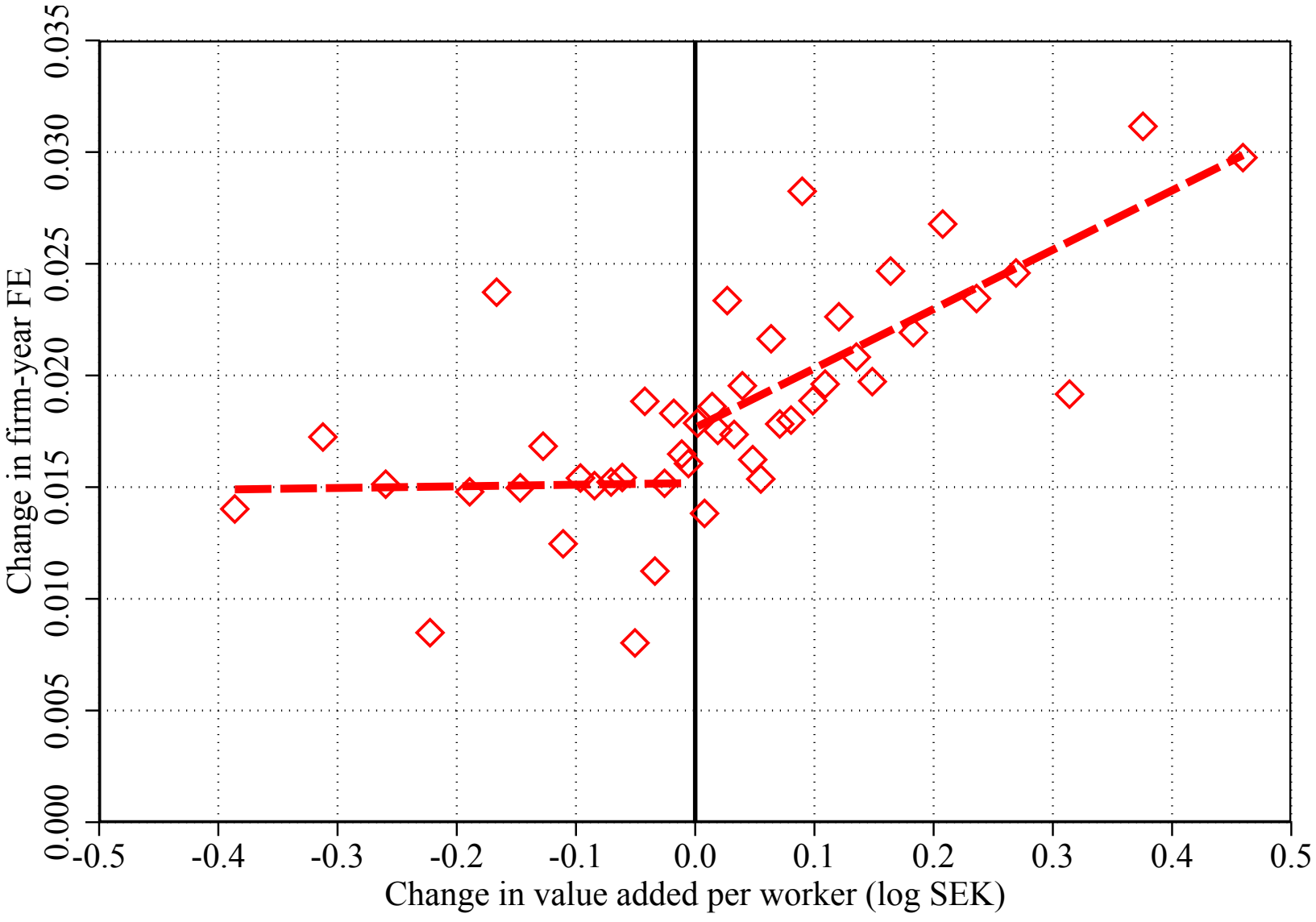


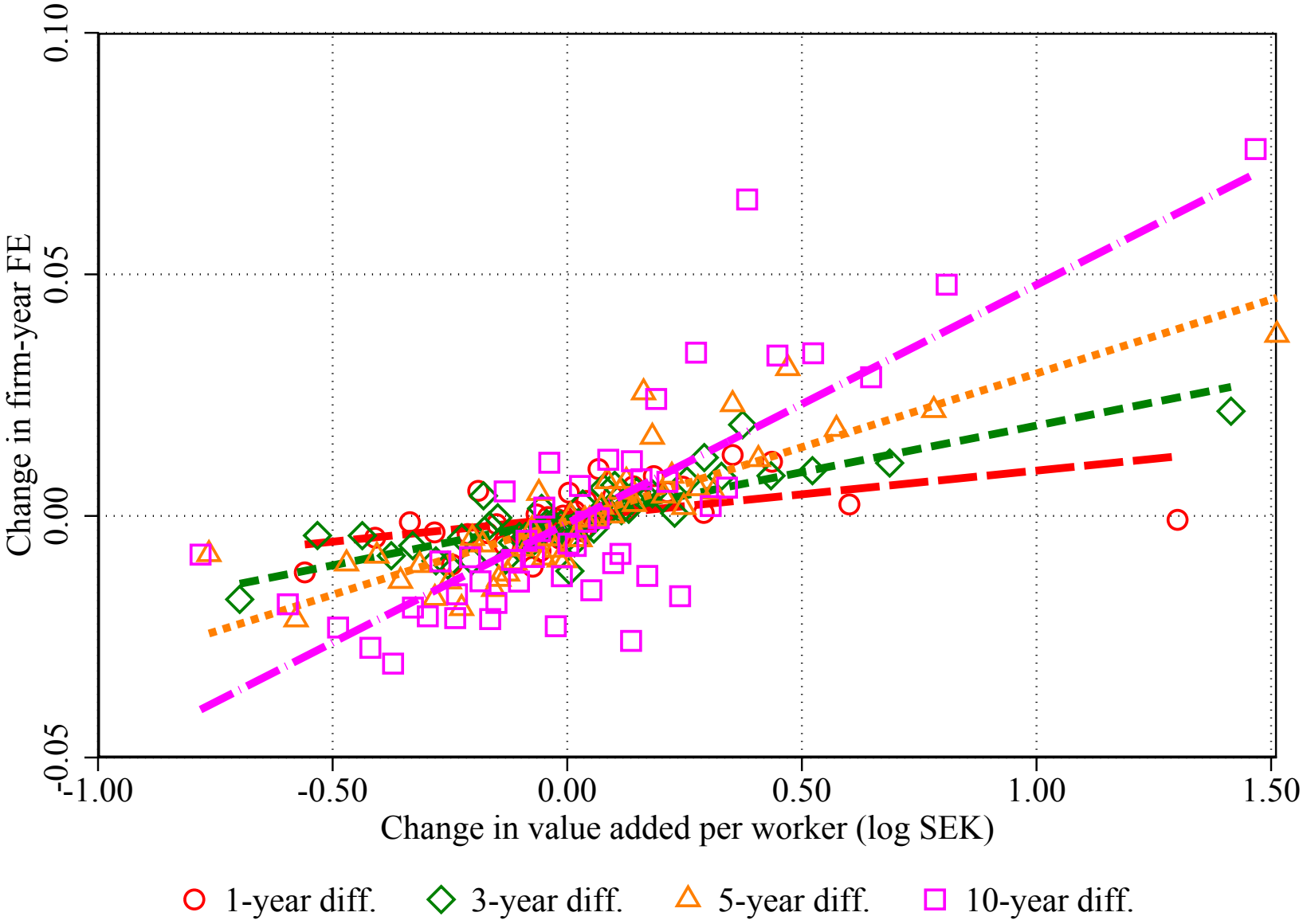
So Firm Pay is Dynamic... But Why?

- So far: systematic and significant dynamics in firm pay
- But why do firms change pay over time?

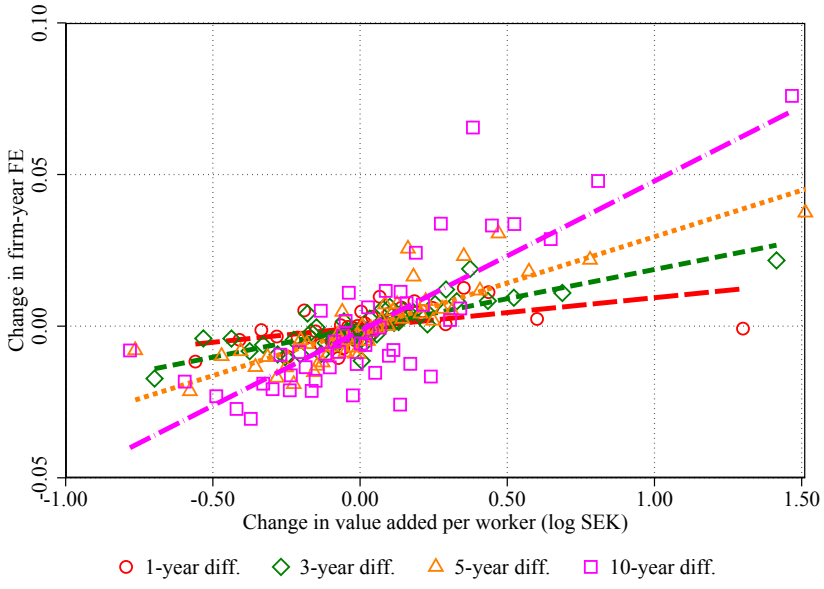
Dynamics in Firm Pay & Value Added

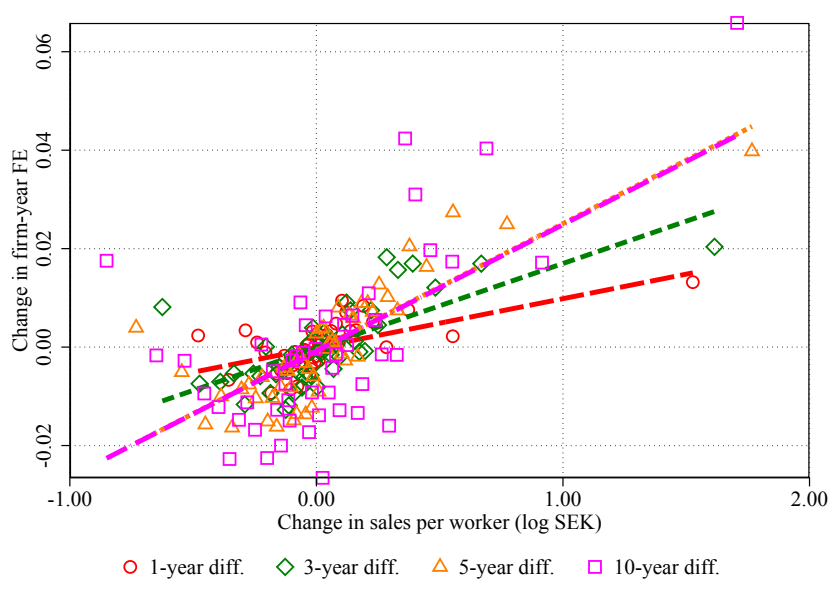


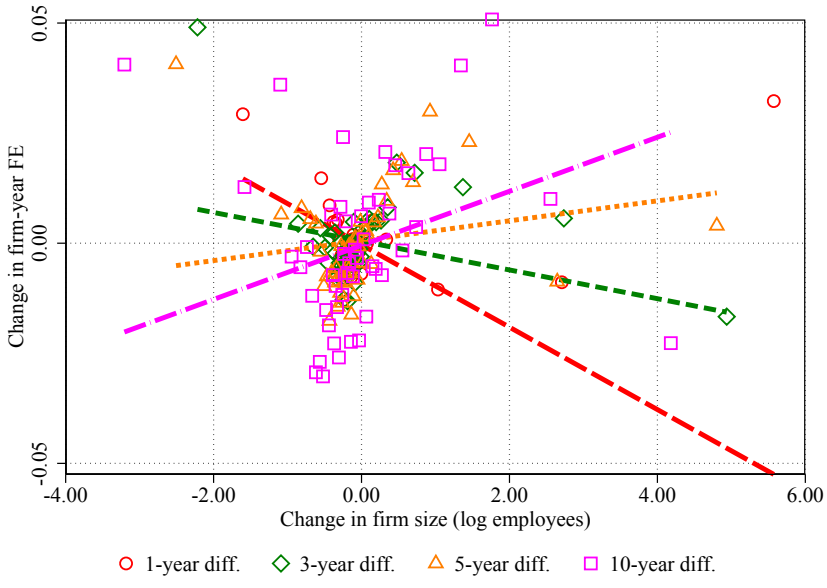
Dynamics in Firm Pay & Value Added, Various Time Horizons



Dynamics in Firm Pay & Observables, Various Time Horizons







Summary: Fluctuations in Firm Pay Policies

Firm-year FEs

1. have fluctuations ($RMSE = 0.056$), mean reversion ($\rho = 0.865$)
2. feature significant mobility, increasing in period length
3. change in relation to changes in firm financials, not just noise

Static & Dynamic Sorting

Static Sorting

- So far, we correlated:
  - estimates of worker FEs with worker characteristics
  - estimates of firm-year FEs with firm characteristics
- To measure sorting, study worker/firm cross-correlations

Definition

Static sorting := cross-sectional matching b/w worker & firm types

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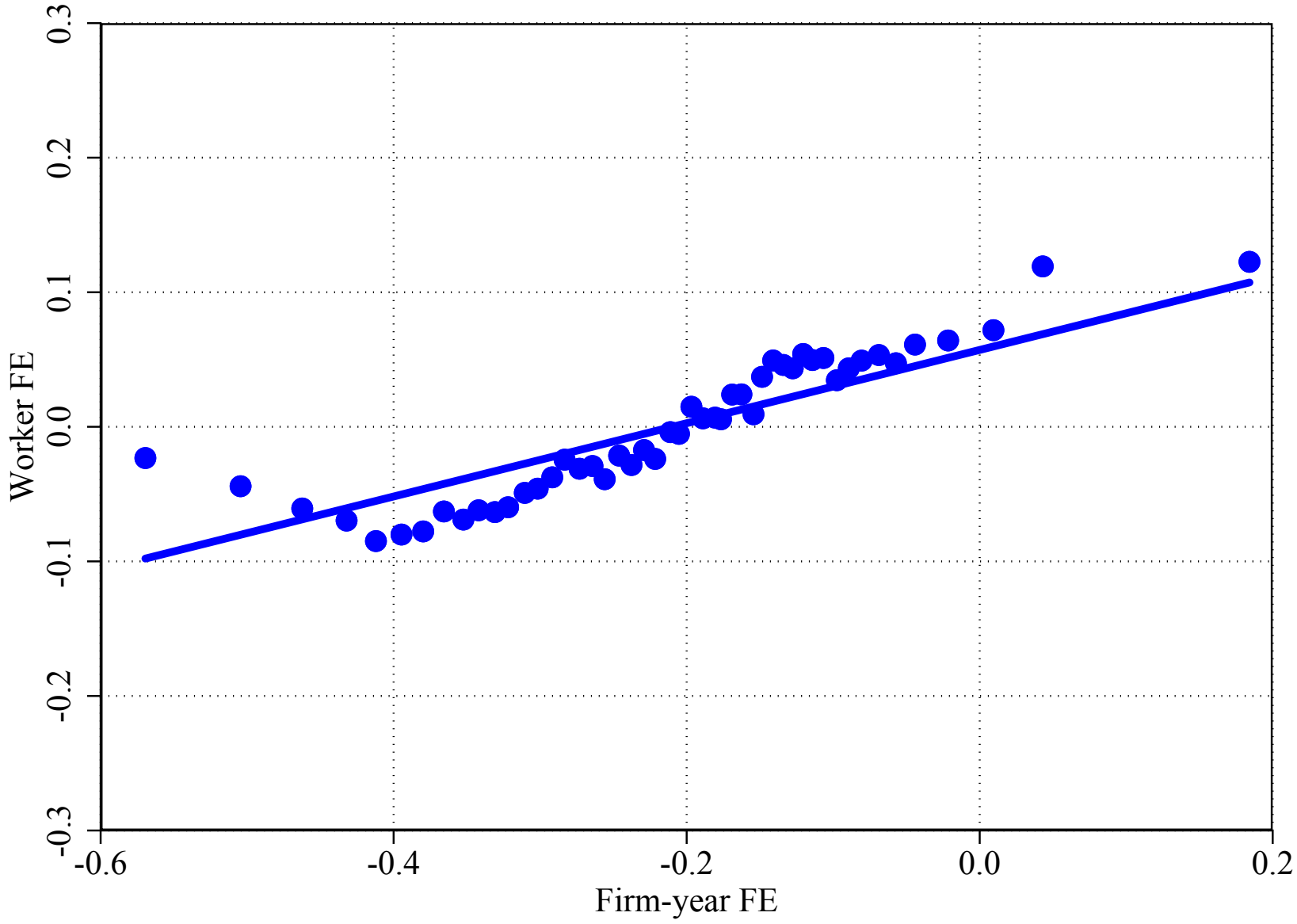
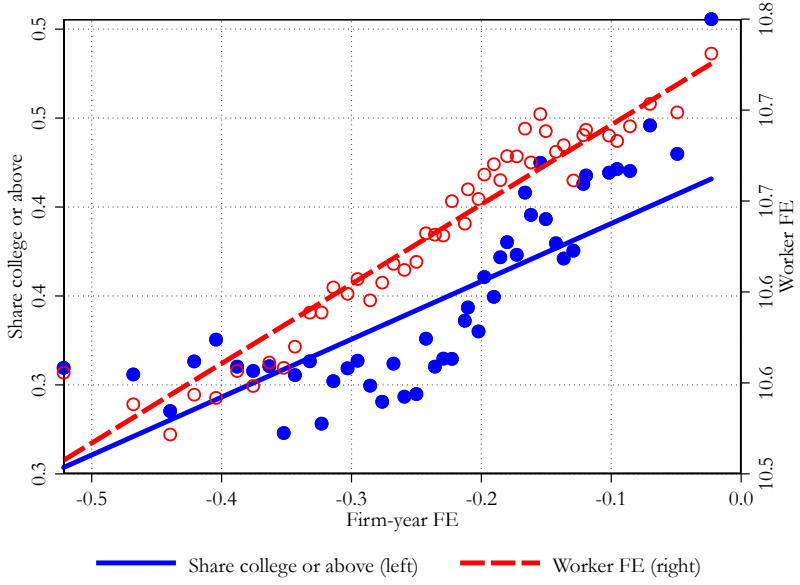
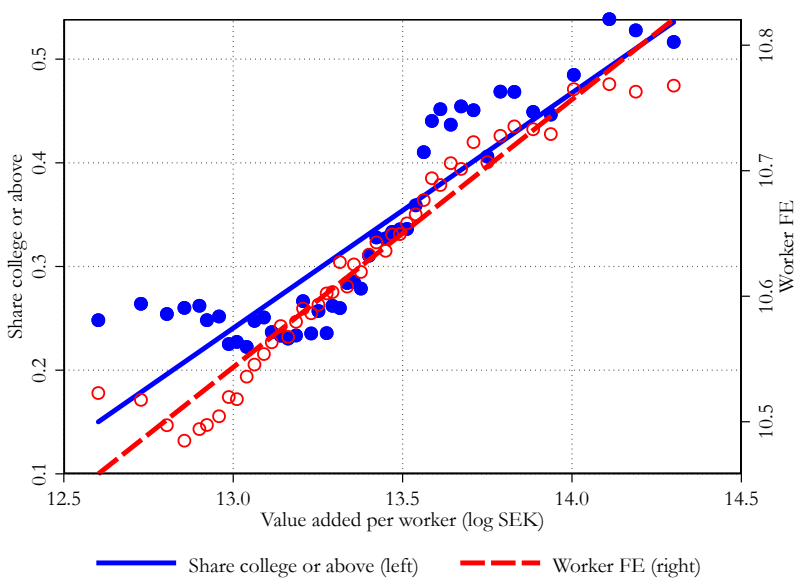
Static sorting := cross-sectional matching b/w worker & firm types

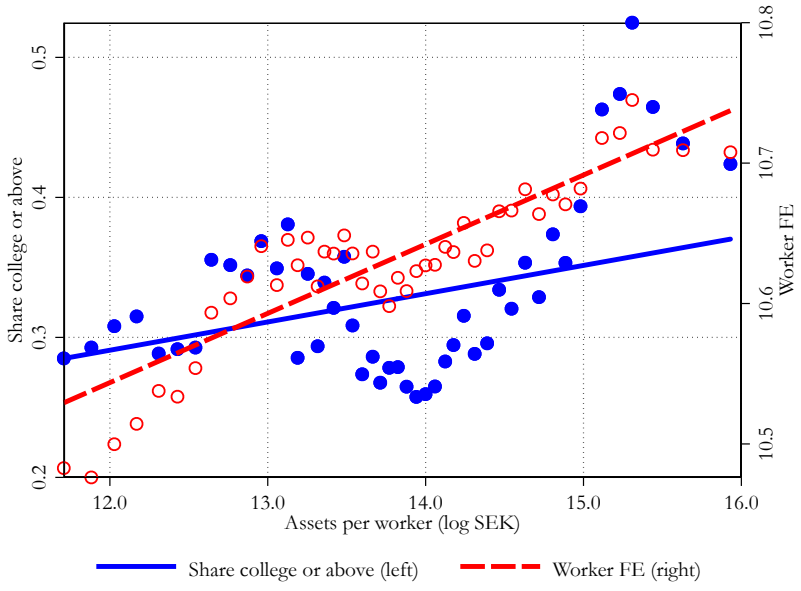
Positive Static Sorting: $\rho = 0.124, \beta = 0.254$



Positive Static Sorting in Observable Dimensions







Dynamic Sorting

- Static sorting may conflate many economic forces
  - E.g., cities attract high-pay firms & workers (Dauth et al. '19)
- Alternative: as firm changes its pay policy, who do they hire?
  - Following very nice paper by Gulyas ('17)

Definition

Dynamic sorting := temporal comovement b/w worker & firm types

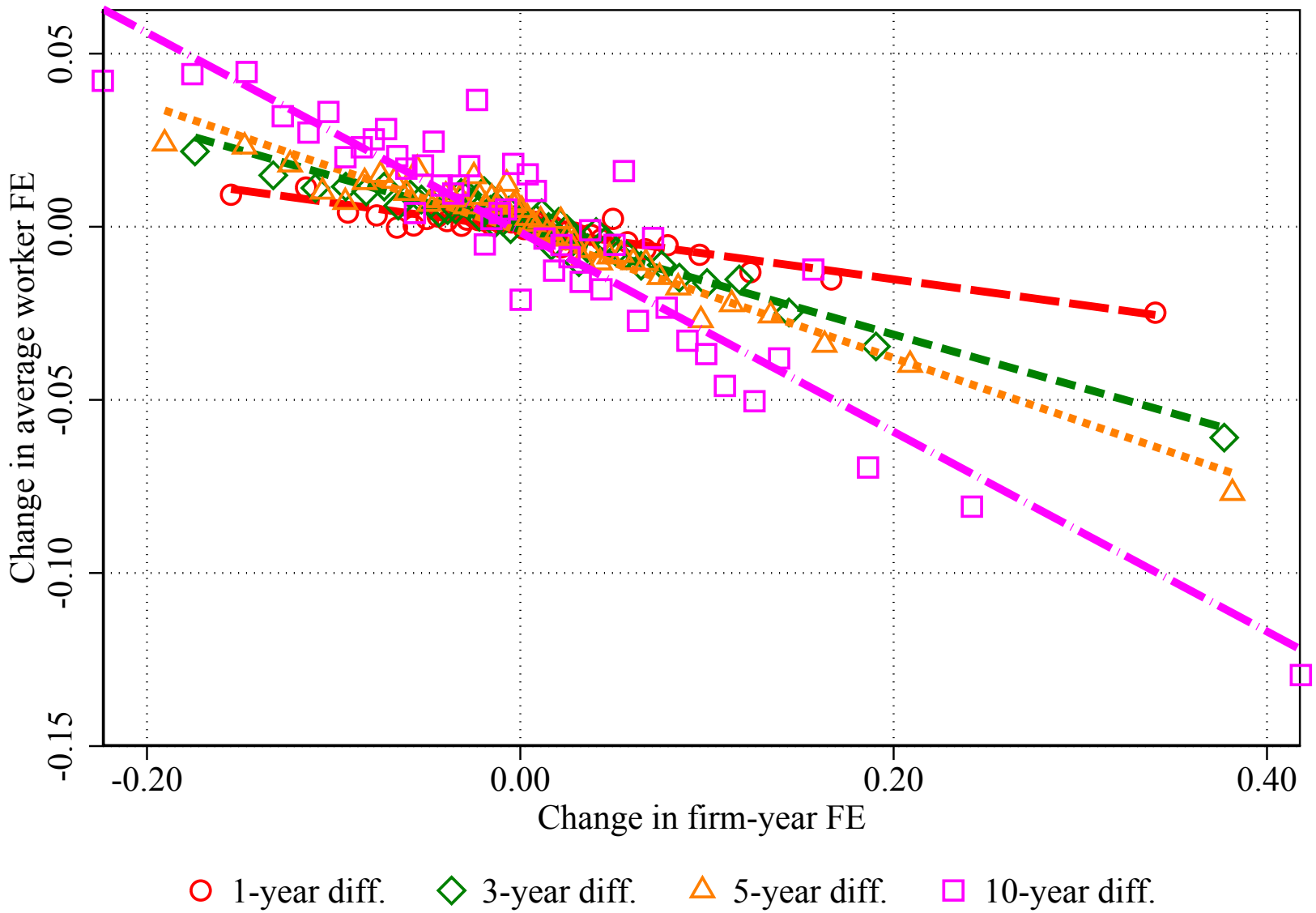
Dynamic Sorting

- Static sorting may conflate many economic forces
  - E.g., cities attract high-pay firms & workers (Dauth et al. '19)
- Alternative: as firm changes its pay policy, who do they hire?
  - Following very nice paper by Gulyas ('17)

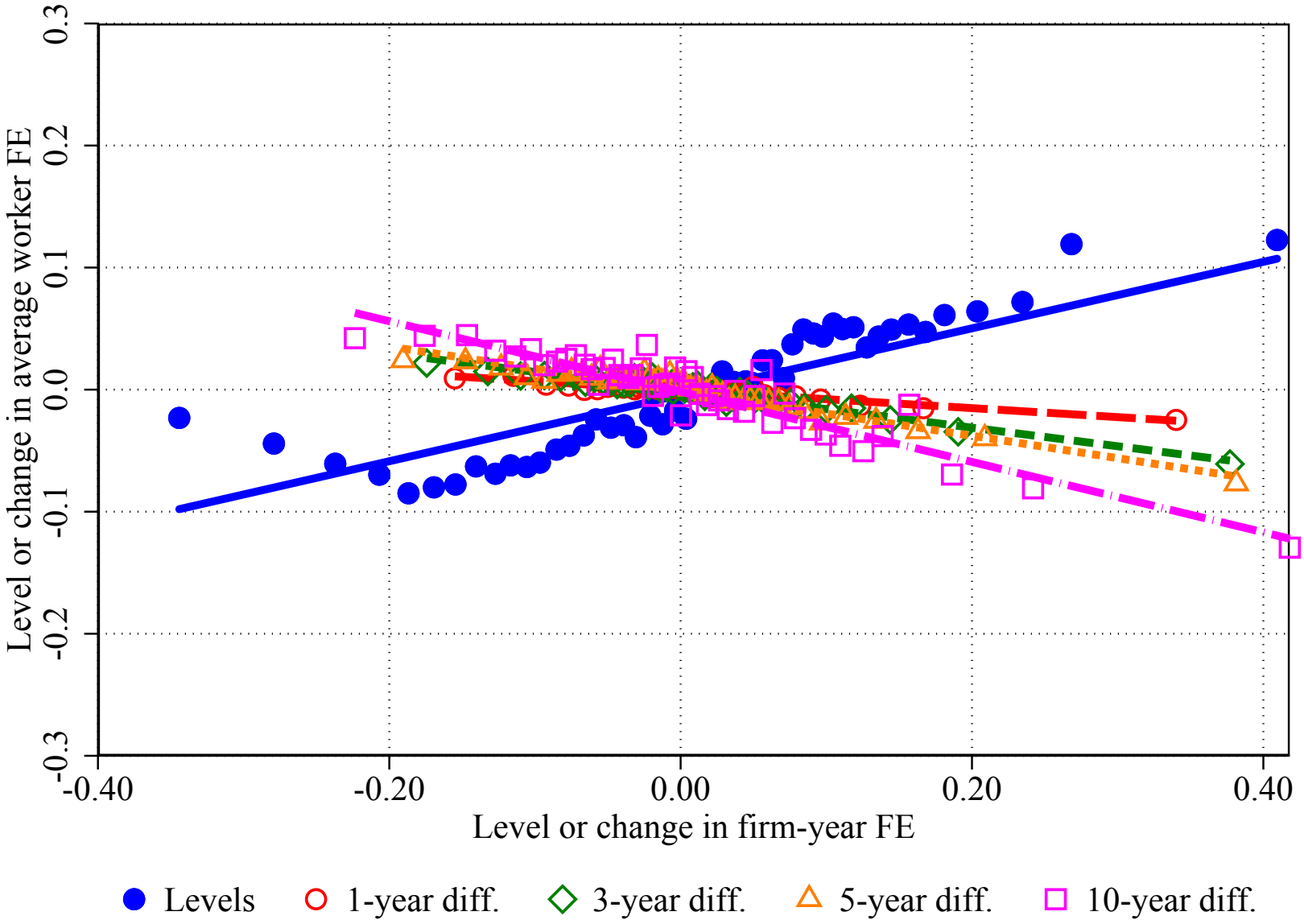
Definition

Dynamic sorting := temporal comovement b/w worker & firm types

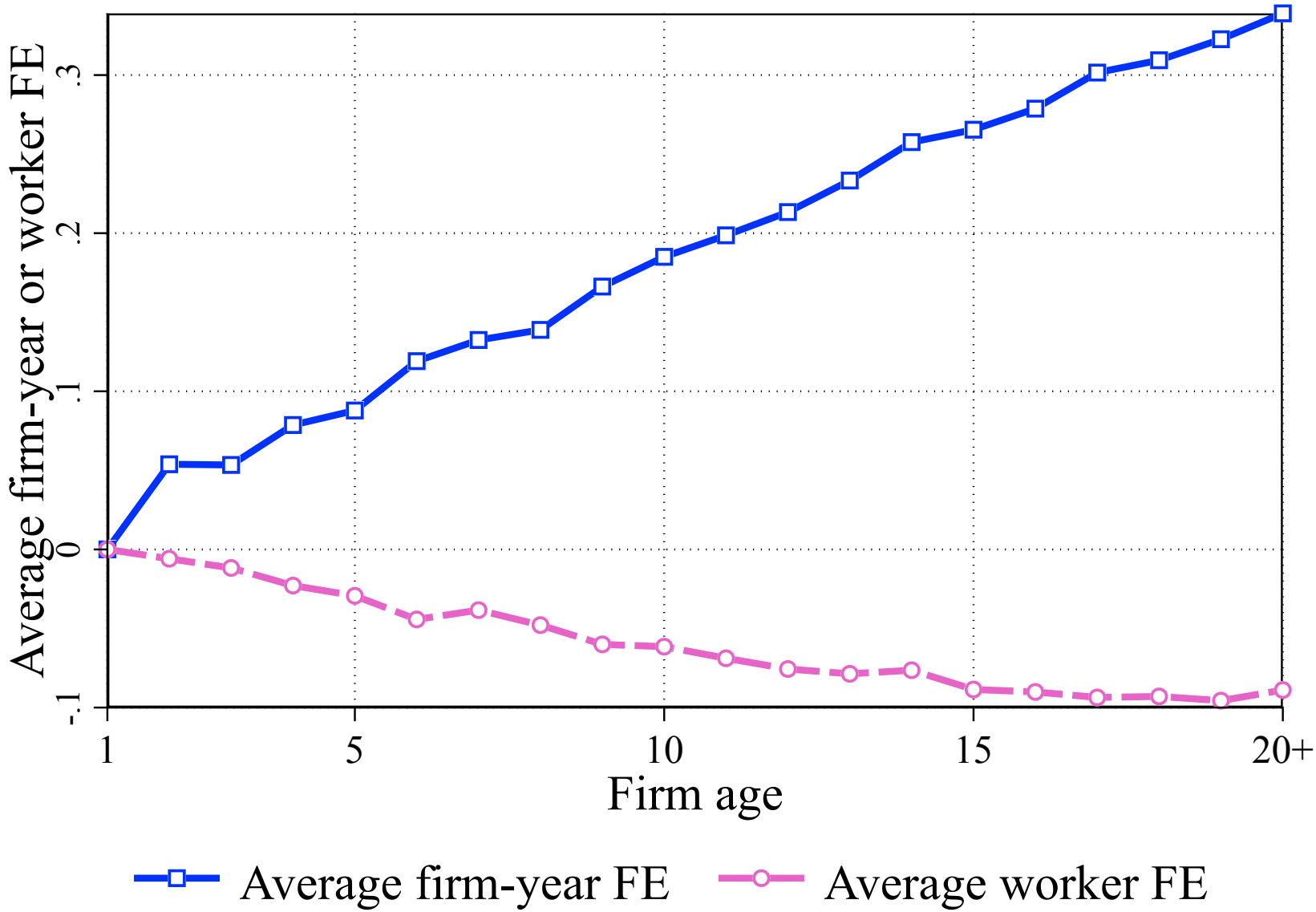
Negative Dynamic Sorting: $\beta \in [-0.071, -0.312]$



Static vs. Dynamic Sorting: A Puzzle?



Resolution: Within-Firm Pay & Worker Composition



Summary: Static and Dynamic Sorting

Firm-year FEs

1. are positively correlated with worker FEs in levels
2. are negatively correlated with worker FEs in differences
3. as firms age, they increase pay but hire lower paid workers

Conclusion

Summary and Key Insight

We find an important role for firm pay dynamics:

1. 50% greater role for firm heterogeneity w/ dynamic pay policies
2. Firm-year pay related to firm financials ($R^2 = 0.385$)
3. Fluctuations ($RMSE = 0.056$) and mean reversion ($\rho = 0.865$)
4. Changes in firm-year pay related to changes in firm financials
5. Sorting is positive in cross section but negative over time

$\Longrightarrow$ Opens up new perspective on (dynamics of) workers and firms!

Appendix

Illustration: 2 firms, 2 years

Back

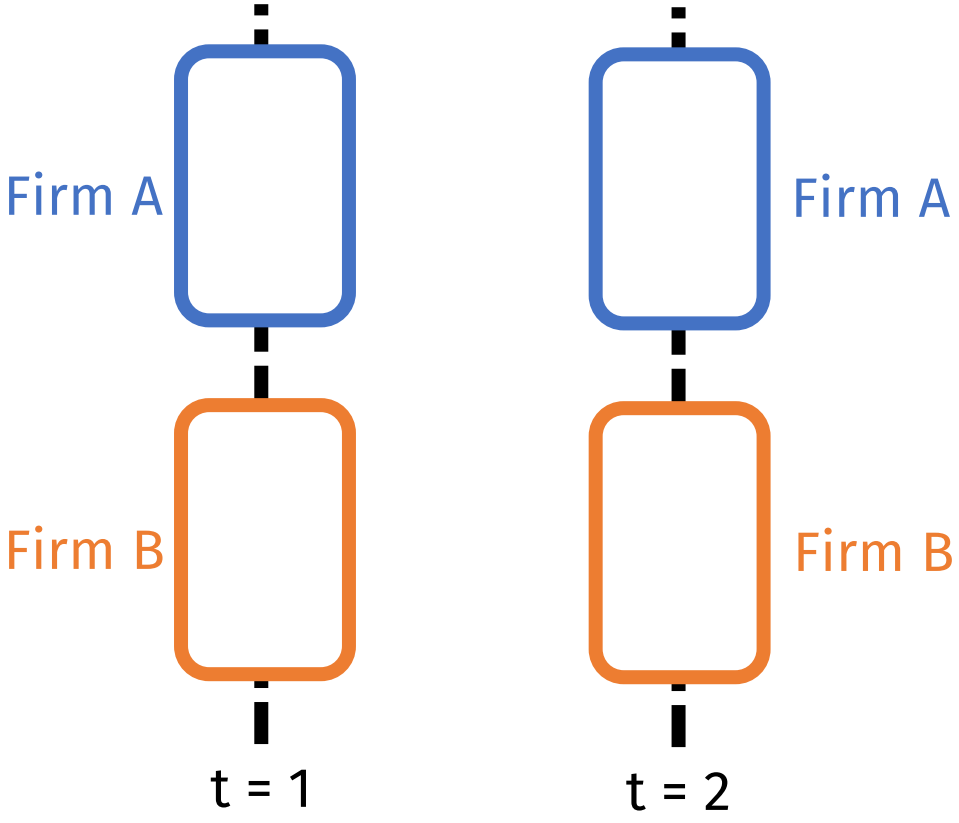


Illustration: 4 firm-years

Back

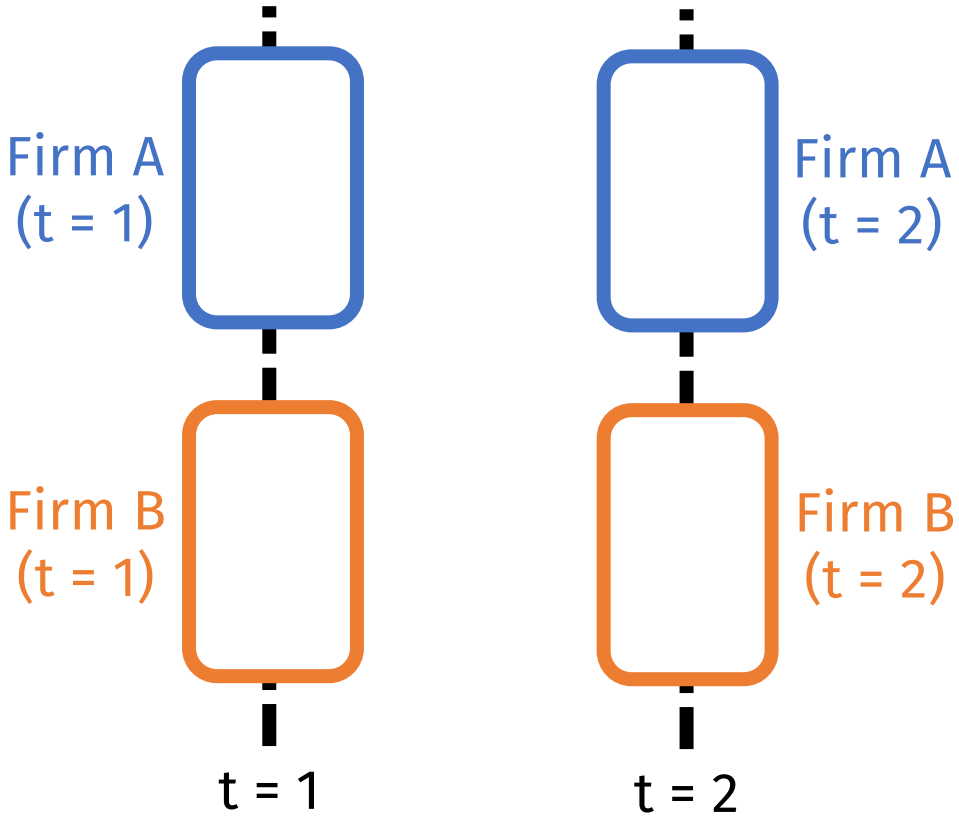


Illustration: Initial worker distribution

Back

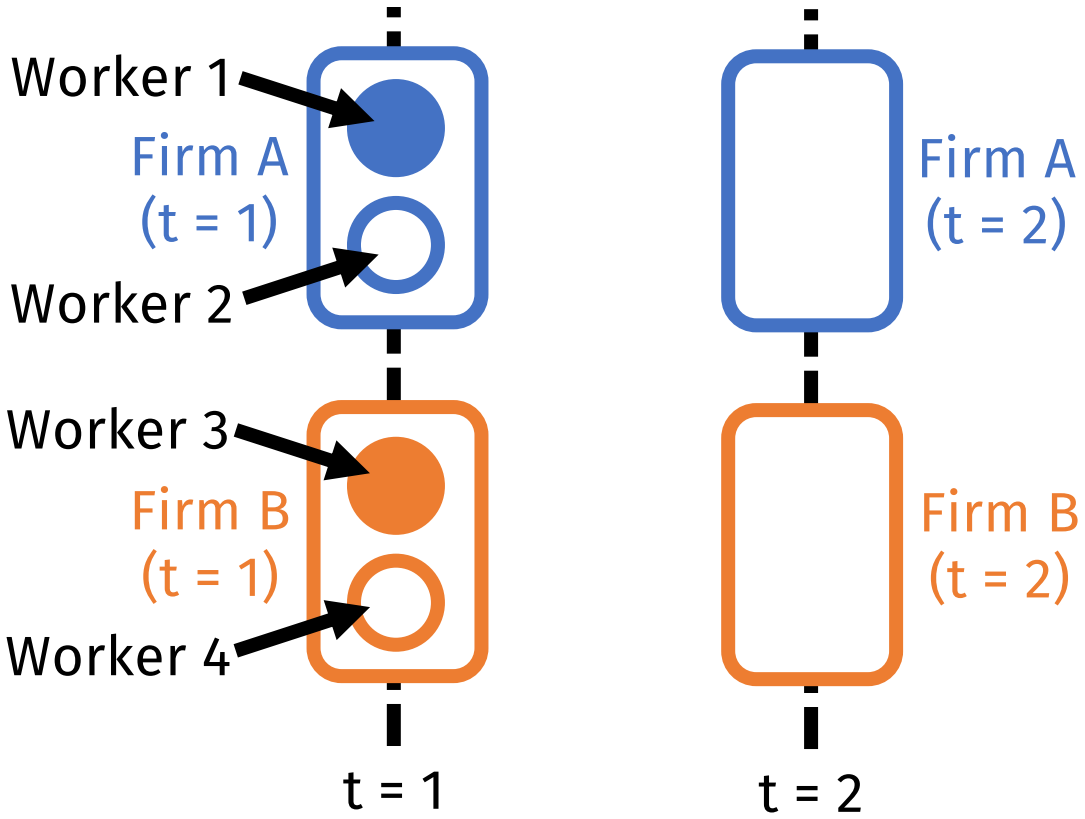


Illustration: No physical switchers

Back

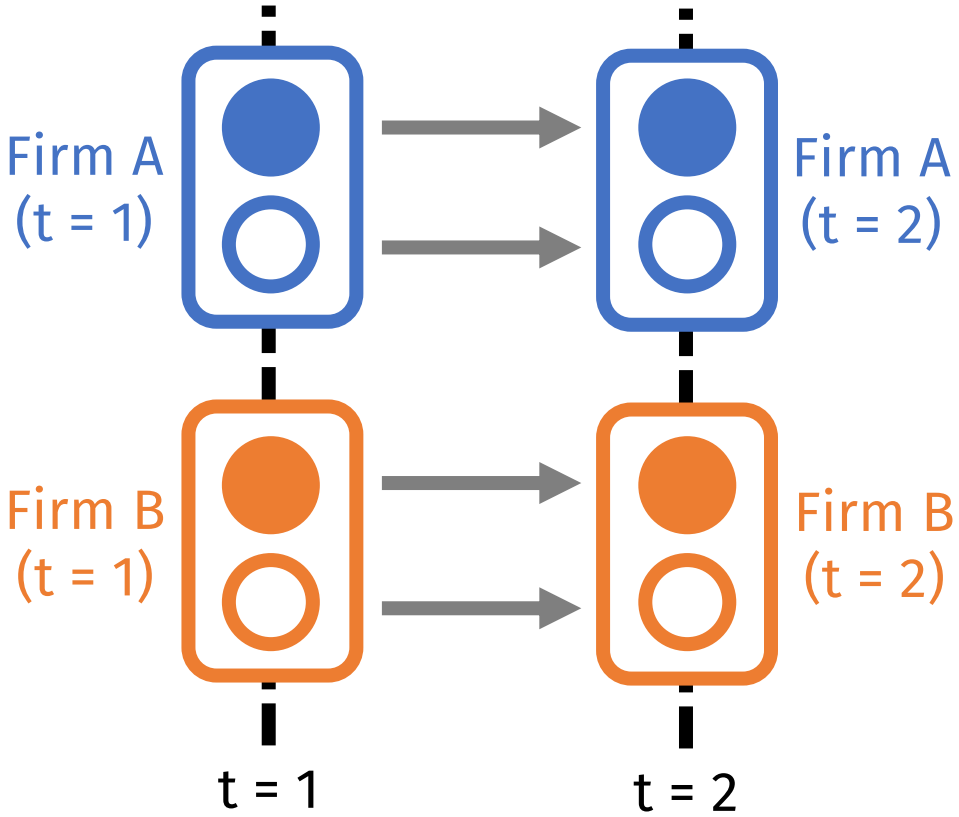


Illustration: Connected sets with no physical switchers

Back

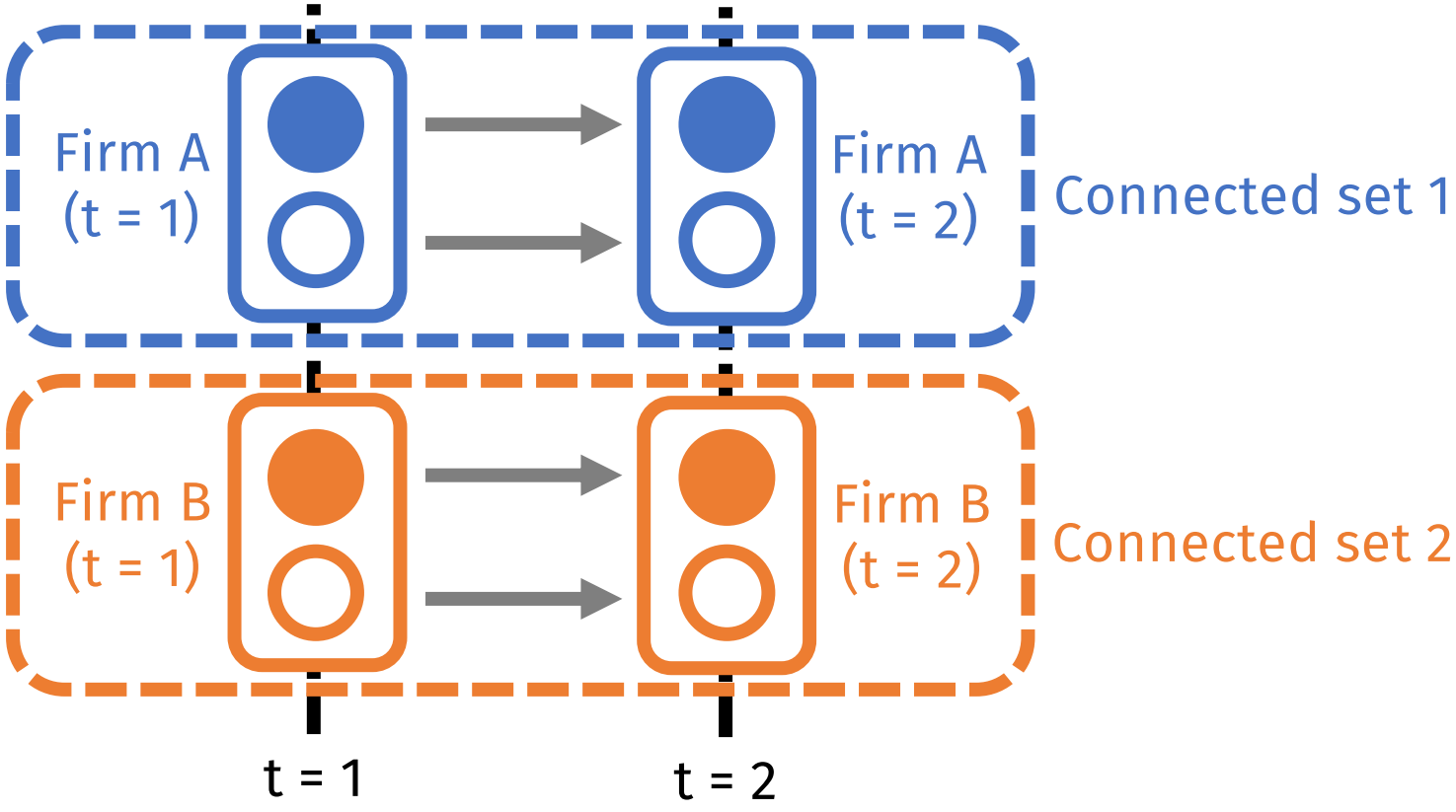


Illustration: Connected set with physical switchers

Back

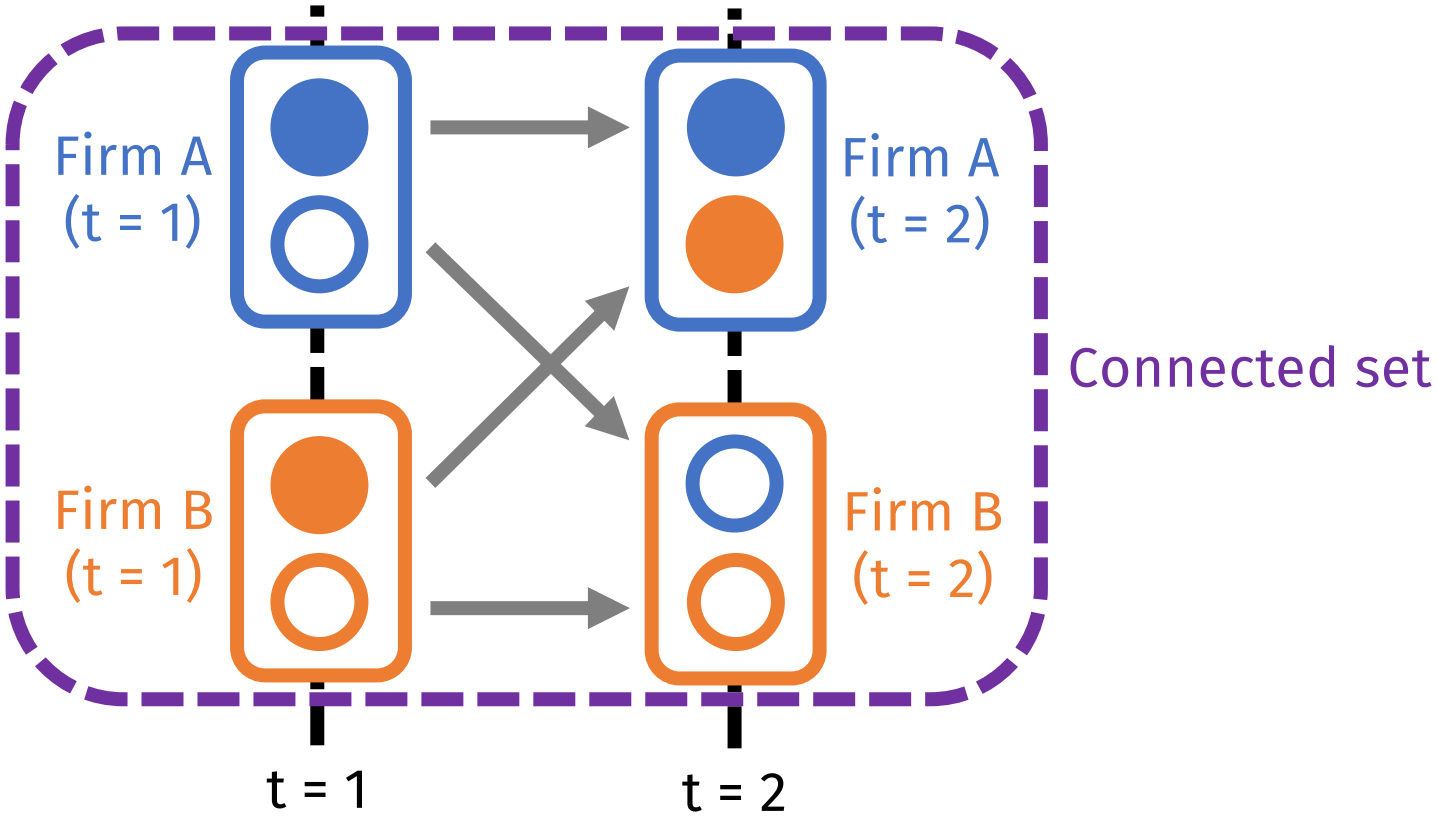


Illustration: Firm exit and entry

Back

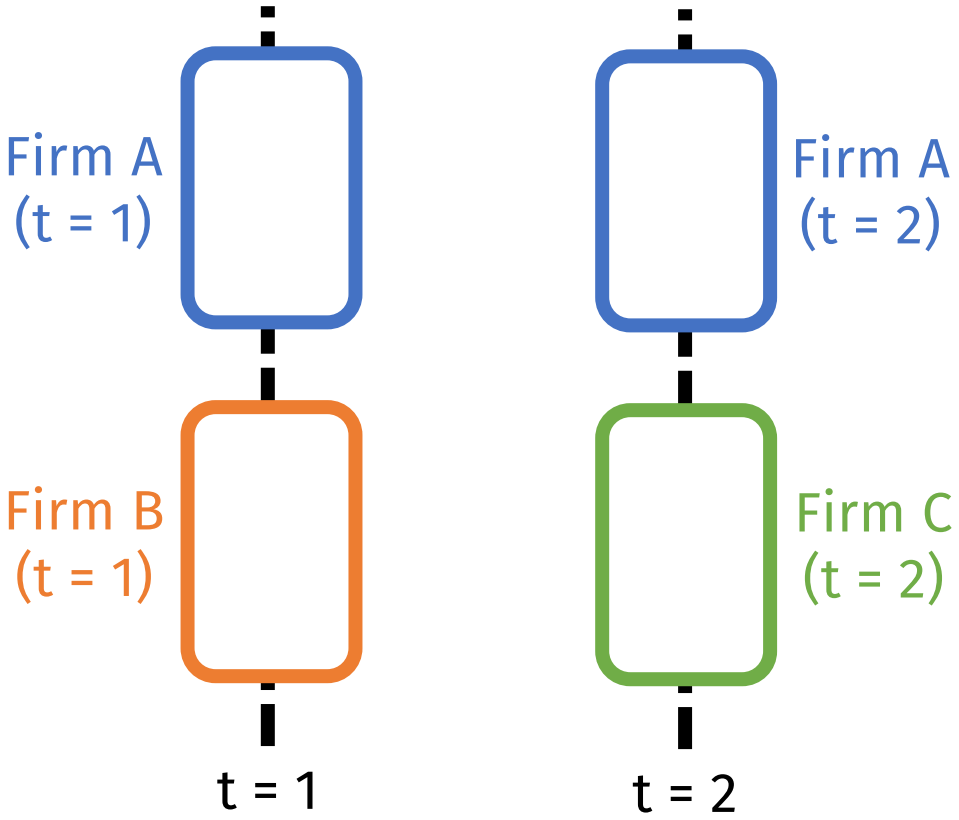


Illustration: Connected set with firm exit and entry (1)

Back

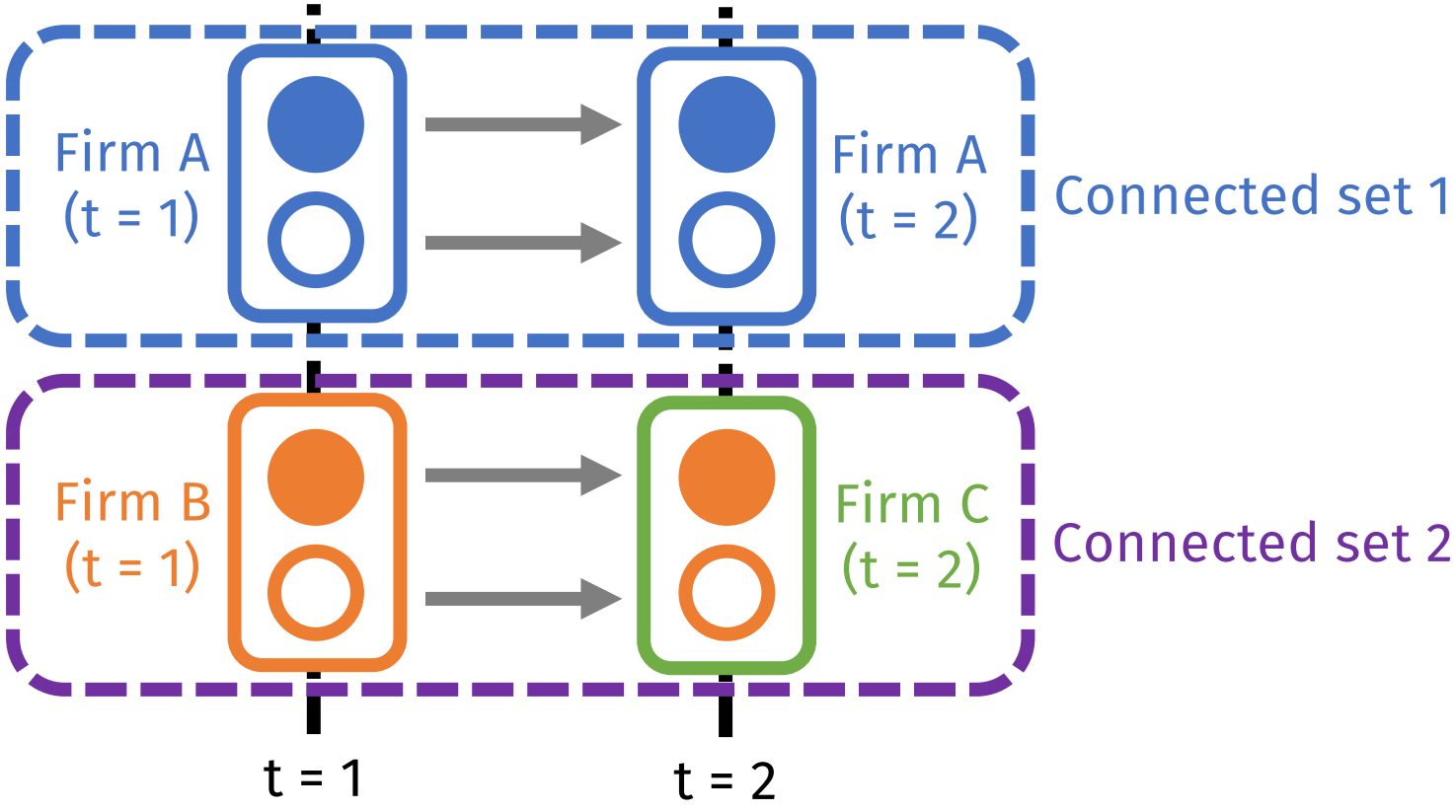


Illustration: Connected set with firm exit and entry (2)

Back

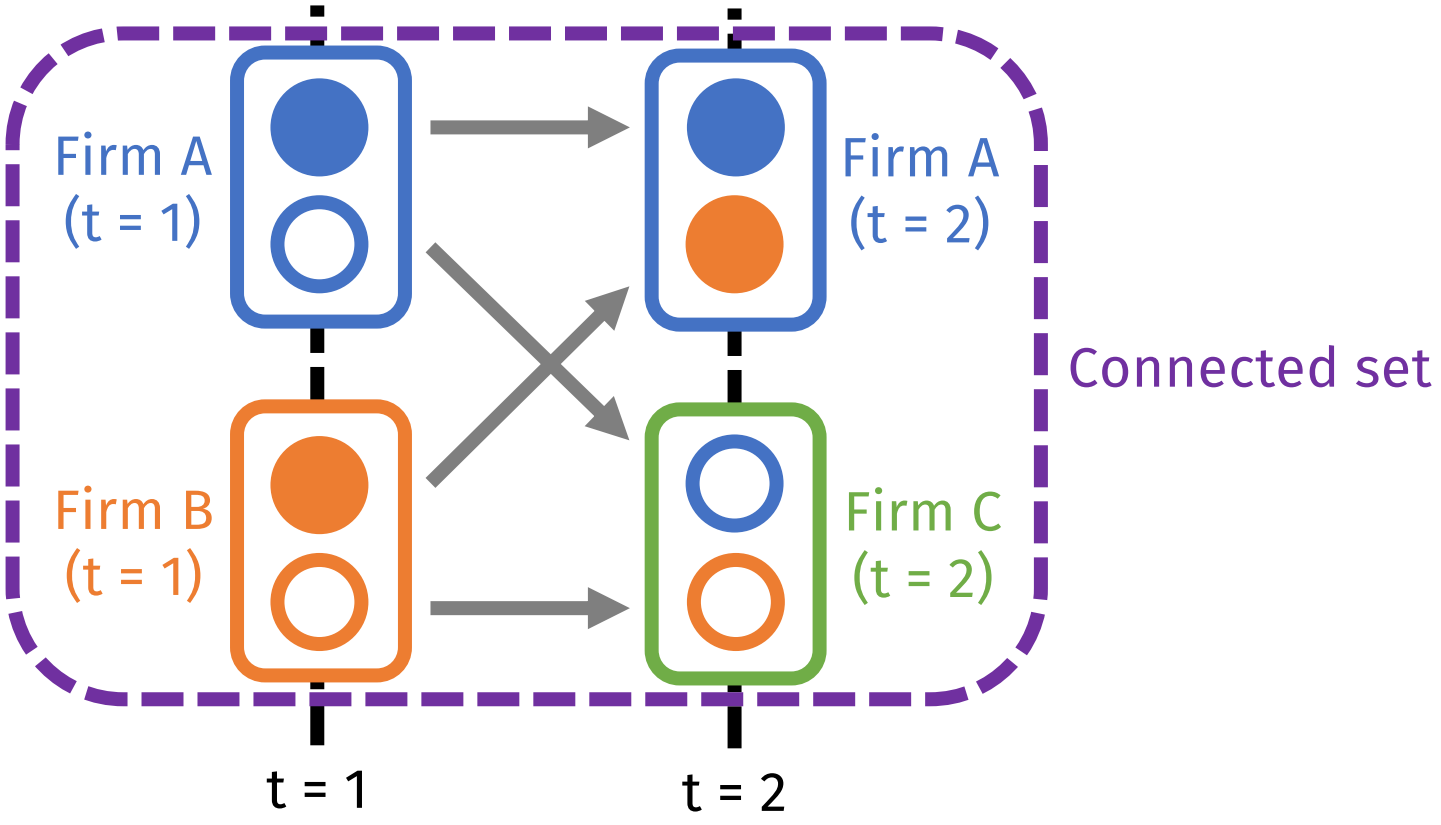
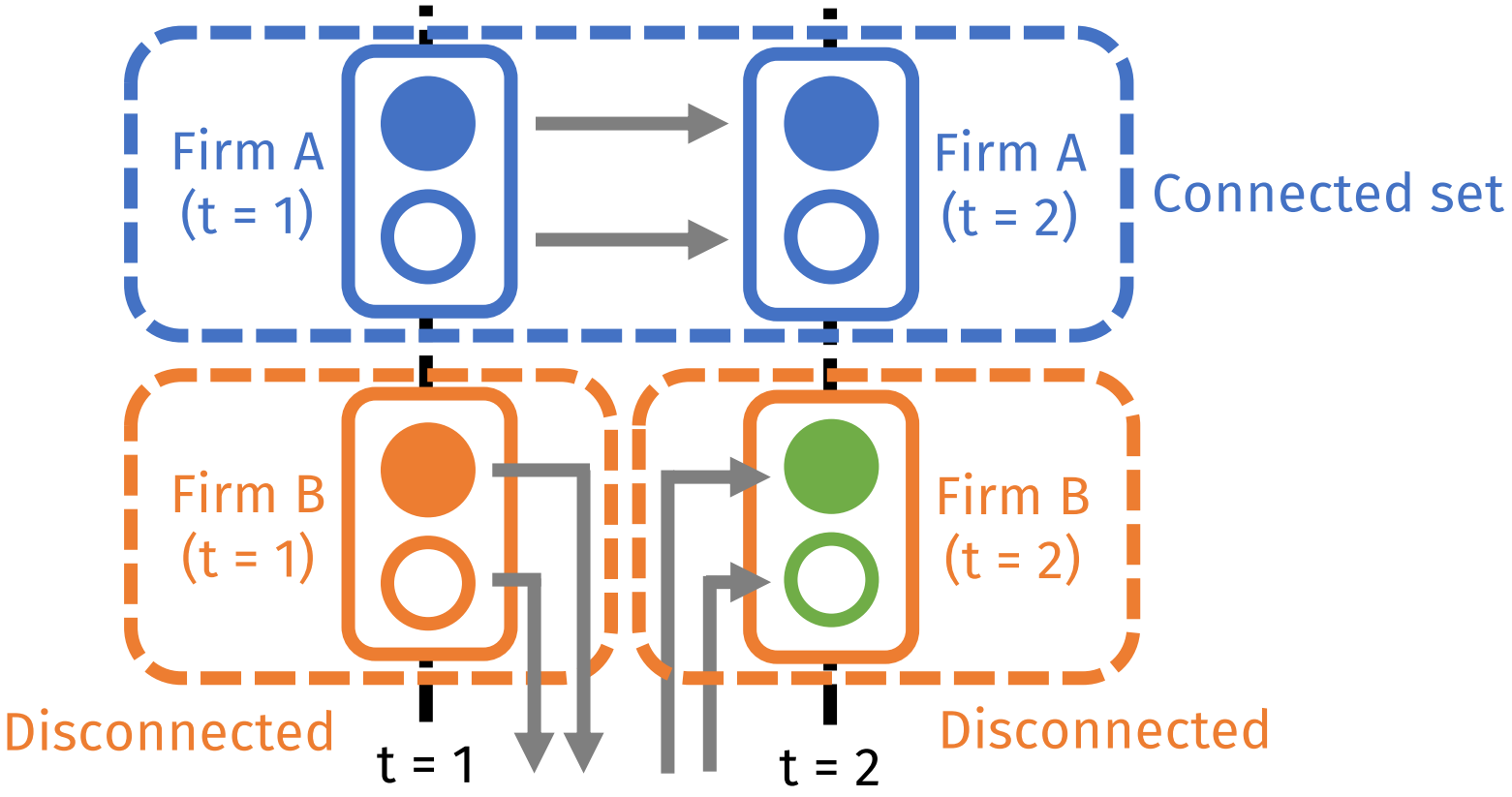


Illustration: Who is not in the connected set?

Back



First Stage Results: Firm FEs instead of Firm-Year FEs

Back

AKM equation: $y_{it} = \alpha_i + \psi_j + X_{it}\beta + \varepsilon_{it}$

	(1)	(2)	(3)	(4)	(5)
$Var\left(y_{ijt}\right)$	0.236	0.230	0.231	0.234	0.235
$Var\left(\widehat{\alpha}_i\right)$	0.121	0.120	0.125	0.130	0.131
$Var\left(\widehat{\psi_j}\right)$	0.032	0.021	0.016	0.013	0.013
$Var\left(\gamma_t\right)$	0.003	0.003	0.003	0.004	0.004
$Var\left(X_{it}\widehat{\beta}\right)$	0.025	0.024	0.022	0.020	0.019
$2 \times \sum Cov\left(\cdot\right)$	0.003	0.012	0.015	0.017	0.019
$Var\left(\widehat{\varepsilon}_{ijt}\right)$	0.051	0.051	0.050	0.050	0.049
$Corr\left(\widehat{\alpha}_i, \widehat{\psi}_{jt}\right)$	0.056	0.134	0.169	0.181	0.182
Observations	21,145,007	18,425,427	15,091,142	11,313,701	9,392,584
Unique workers	3,056,376	2,801,551	2,437,724	1,959,034	1,685,029
Unique firms	411,361	112,262	33,754	8,303	3,656
Largest connected set	98.5%	99.9%	100.0%	100.0%	100.0%
R^2	0.782	0.779	0.783	0.788	0.790
Firm FE type	Firm	Firm	Firm	Firm	Firm
Income concept	Earnings	Earnings	Earnings	Earnings	Earnings
Minimum firm size	0	5	15	50	100

First Stage Results: Wages instead of Earnings

Back

AKM equation: $y_{it} = \alpha_i + \psi_{jt} + X_{it}\beta + \varepsilon_{it}$

	(1)	(2)	(3)
$Var\left(y_{ijt}\right)$	0.124	0.124	0.124
$Var\left(\widehat{\alpha}_i\right)$	0.089	0.089	0.089
$Var\left(\widehat{\psi}_{jt}\right)$	0.009	0.009	0.008
$Var\left(X_{it}\widehat{\beta}\right)$	0.012	0.012	0.012
$2 \times \sum Cov\left(\cdot\right)$	0.007	0.007	0.008
$Var\left(\widehat{\varepsilon}_{ijt}\right)$	0.007	0.007	0.007
$Corr\left(\widehat{\alpha}_i, \widehat{\psi}_{jt}\right)$	0.080	0.082	0.087
Observations	8,067,111	8,021,504	7,825,645
Unique workers	1,640,798	1,624,288	1,570,087
Unique firms	85,833	64,050	41,264
Largest connected set	99.5%	99.8%	100.0%
R^2	0.944	0.944	0.943
Firm FE type	Firm-year	Firm-year	Firm-year
Income concept	Wage	Wage	Wage
Minimum firm size	0	5	15

Second Stage: Firm Pay & Observables, by Firm Size

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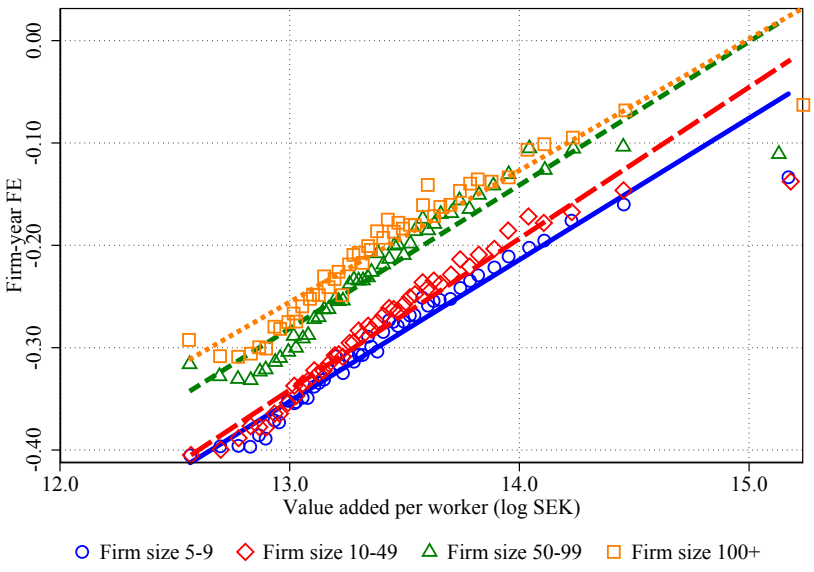
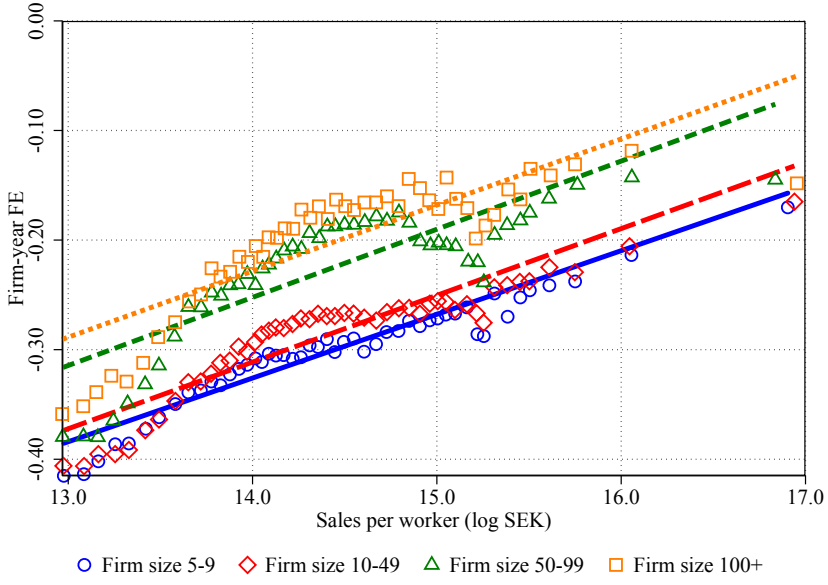
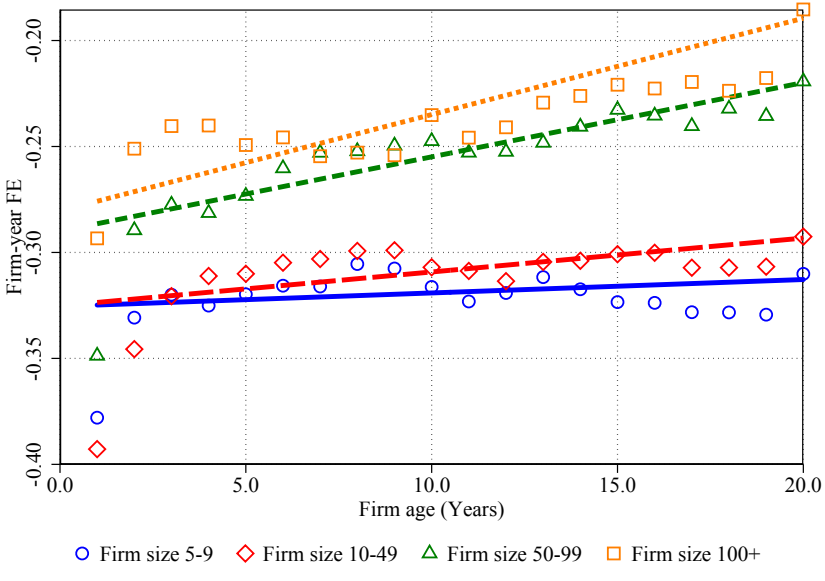
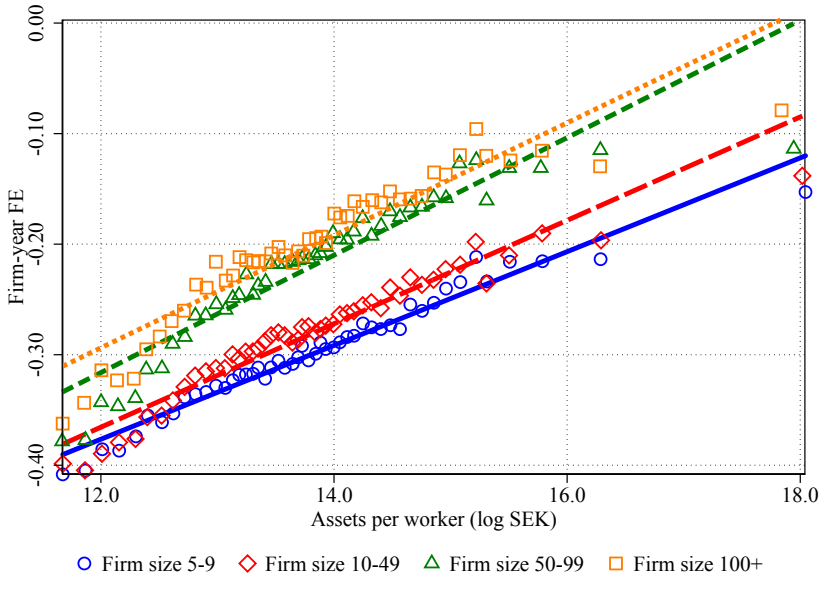


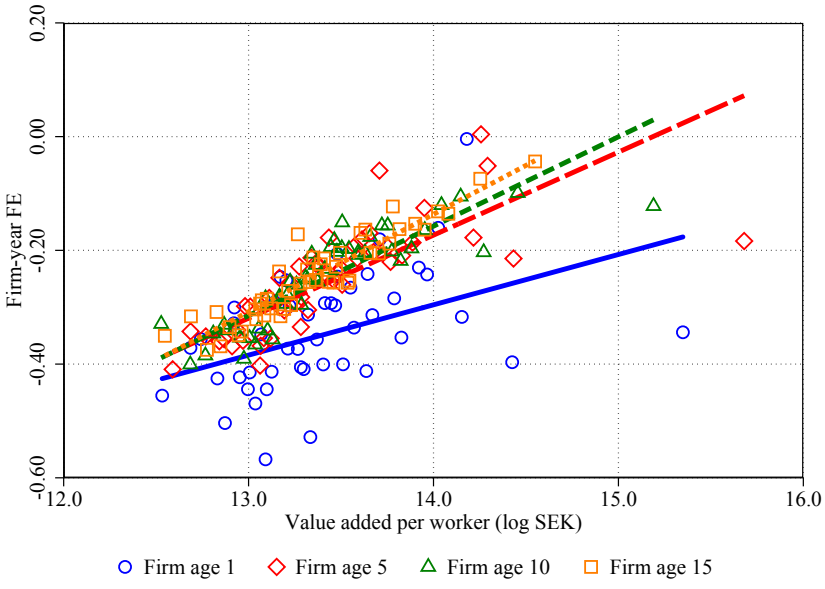


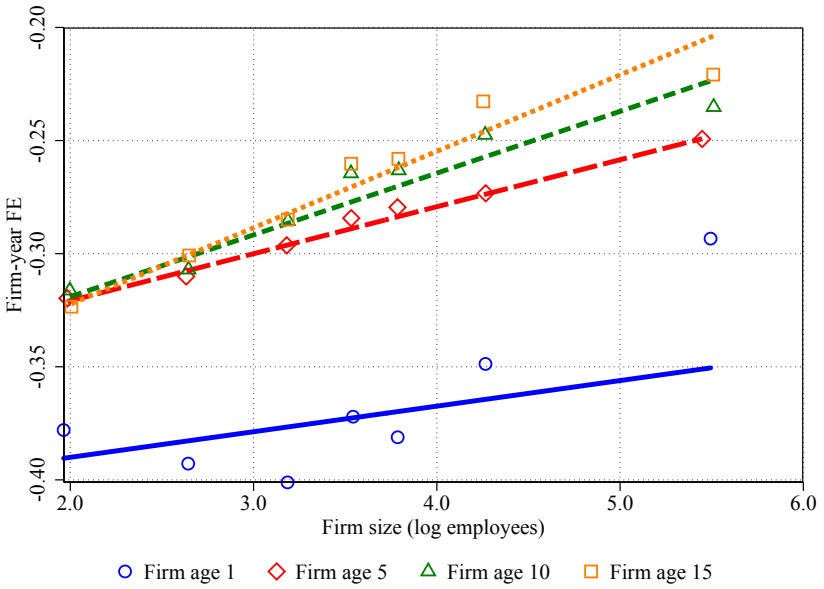


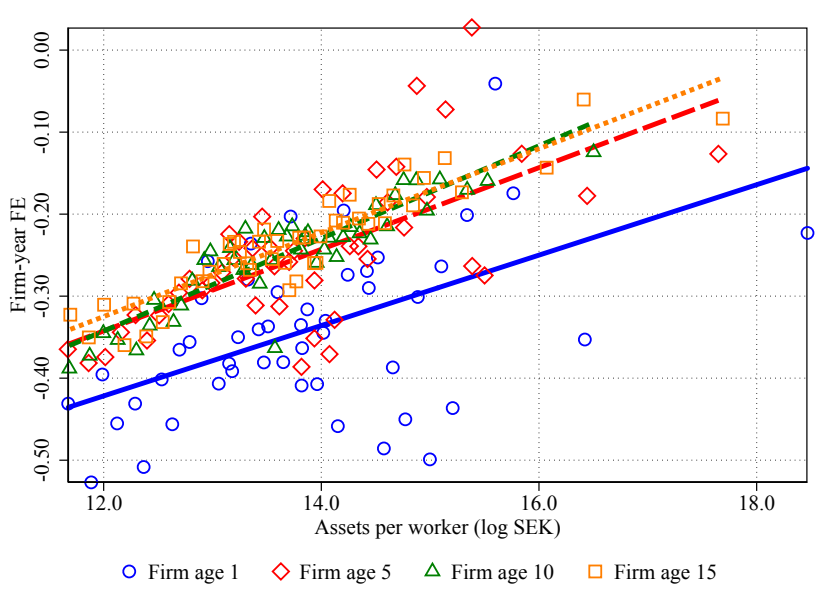


Second Stage: Firm Pay & Observables, by Firm Age

Back







Second Stage: Worker Pay & Observables, Added Firm FEs

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	(1) Univariate	(2) Multivariate	(3) Univariate	(4) Multivariate
Firm size (log employees)	0.023	0.008	0.004	0.001
Firm age (years)	0.035	-0.002	0.023	0.017
Sales per worker (log SEK)	0.070	0.013	0.009	0.005
Value added per worker (log SEK)	0.121	0.056	0.011	0.011
Assets per worker (log SEK)	0.056	0.014	0.004	-0.018
Debt per worker (log SEK)	0.056	0.018	0.005	0.018
Equity per worker (log SEK)	0.036	0.004	0.001	0.003
Investment per worker (log SEK)	0.022	-0.004	0.000	-0.000
Observations	13,865,483	13,865,483	13,421,121	13,421,121
R^2		0.385		0.830
Year FE	Yes	Yes	Yes	Yes
Firm FE	No	No	Yes	Yes
Income concept	Earnings	Earnings	Earnings	Earnings
Minimum firm size	15	15	15	15

Second Stage: Worker Pay & Observables, Larger Firms

Back

	(1) Univariate	(2) Multivariate	(3) Univariate	(4) Multivariate
Firm size (log employees)	0.023	0.008	0.014	0.006
Firm age (years)	0.035	-0.002	0.033	-0.006
Sales per worker (log SEK)	0.070	0.013	0.070	0.016
Value added per worker (log SEK)	0.121	0.056	0.116	0.053
Assets per worker (log SEK)	0.056	0.014	0.053	0.008
Debt per worker (log SEK)	0.056	0.018	0.053	0.019
Equity per worker (log SEK)	0.036	0.004	0.035	0.007
Investment per worker (log SEK)	0.022	-0.004	0.023	-0.003
Observations	13,865,483	13,865,483	10,521,969	10,521,969
R^2		0.385		0.417
Year FE	Yes	Yes	Yes	Yes
Income concept	Earnings	Earnings	Earnings	Earnings
Minimum firm size	15	15	50	50